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VOLUME I

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Issues and Options

Volume I

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This report has three primary objectives: 1) to identify waste minimization practices in the United States by major industry processes and by major waste stream; to identify factors that promote and inhibit the adoption of waste minimization practices by industry; and to identify strategies by which waste minimization can be increased. The report also serves as a resource document on waste minimization for Federal and State programs industries, and the general publin. It must be noted that this study approval has the objectives stated above in an exploratory manner because of the size, diversity, and complexity of the subject.

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Waste Minimization Issues and Options
Volume I

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TABLE OF CONTENTS

Page No.

EXECUTIVE SUMMARY ES-1

PREFACE 1

1. DEFINITION AND SCOPE OF WASTE MINIMIZATION 1-1

   1.1 Background and Scope of the "Waste Minimization" Definition 1-3
   1.2 Background and Scope of the Issue of Burning for Energy as a Recycling Activity 1-4

2. WASTE GENERATION PROFILE 2-1

   2.1 Causes of Waste Generation 2-1
   2.2 Industry-Specific Waste Generation Profile 2-6
      2.2.1 Characteristic Waste Stream Generation and Recycling 2-16
      2.2.2 Generation and Management Profile by Waste Category 2-18
   2.3 Process - Specific Waste Generation Profile 2-29
   2.4 Summary 2-36

3. SOURCE REDUCTION PROFILE 3-1

   3.1 Source Control Methodology 3-2
      3.1.1 Input Material Alteration 3-2
      3.1.2 Technology Modifications 3-5
      3.1.3 Procedural/Institutional Modifications 3-11
   3.2 Current and Future Extent of Waste Minimization through Source Control 3-13
   3.3 Product Substitution 3-22
   3.4 Summary of Findings and Observations 3-28

4. WASTE RECYCLING PROFILE 4-1

   4.1 Characterization of Recycling Practices and Technologies 4-1
   4.2 Current Extent of Recycling 4-3
      4.2.1 Industry-Specific Profile 4-3
      4.2.2 Waste-Specific Profile 4-7
      4.2.3 Recycling Technology Profile 4-22
   4.3 Offsite Recycling 4-43
      4.3.1 Commercial Recycling Facilities 4-43
      4.3.2 Waste Exchanges 4-45
   4.4 Future Extent of Recycling 4-58
   4.5 Summary 4-61

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Page No.

5. FACTORS THAT PROMOTE OR INHIBIT WASTE MINIMIZATION 5-1

5.1 Economic Aspects and Technological Innovation 5-1
5.1.1 A Firm's Decision to Invest 5-2
5.1.2 Investment in Innovative Technology 5-5
5.1.3 Investment in Waste Minimization 5-7
5.2 Liability Aspects 5-11
5.2.1 Inability to Obtain Insurance 5-11
5.2.2 Cleanup Costs 5-15
5.2.3 Liability as an Incentive for Onsite and Offsite Recycling 5-22
5.3 Organizational and Attitudinal Aspects 5-25
5.3.1 The Organization of Environmental Programs within Firms 5-26
5.3.2 Company Policy-Making and Policy Implementation Processes 5-29
5.3.3 Industry Perception of RCRA 5-31
5.3.4 Origins of Opposition to Change 5-33
5.4 Consumer Attitudes and Public Relations Issues 5-36
5.5 Regulatory Aspects 5-38
5.5.1 Waste Minimization Certifications 5-39
5.5.2 EPA's Definition of Solid Waste 5-41
5.5.3 Land Disposal Restrictions 5-48
5.5.4 Technological and Other Requirements for New and Existing TSD Facilities 5-56
5.5.5 Siting 5-58
5.5.6 Permitting Issues 5-62
5.5.7 Delisting Issues 5-65
5.6 Summary 5-66

6. INDUSTRY EFFORTS TOWARDS WASTE MINIMIZATION 6-1

6.1 Description of Information Base 6-1
6.2 Observed Trends in Industrial Waste Minimization Efforts 6-2
6.3 Capital Outlays, Annual Savings, and Payback Period ... 6-4
6.4 Summary 6-6

7. GOVERNMENT AND NONINDUSTRY EFFORTS TOWARD WASTE MINIMIZATION 7-1

7.1 Congressional Initiatives 7-1
7.1.1 Congressional Budget Office 7-1
7.1.2 Office of Technology Assessment 7-2

TABLE OF CONTENTS (continued)

Page No.

7.2 National Research Council 7-3
7.3 Federal Agencies 7-4
  7.3.1 Environmental Protection Agency 7-4
  7.3.2 Department of Energy 7-8
  7.3.3 Department of Defense 7-9
  7.3.4 Bureau of Mines 7-16
  7.3.5 Tennessee Valley Authority 7-17
7.4 State and Local Efforts 7-19
  7.4.1 Regulatory Programs 7-19
  7.4.2 Fee and Tax Incentives 7-25
  7.4.3 Loan and Bond Assistance 7-33
  7.4.4 Grant Programs 7-36
  7.4.5 Information Programs 7-37
  7.4.6 Award Programs 7-42
7.5 Nongovernmental, Nonindustrial Efforts 7-43
  7.5.1 League of Women Voters 7-43
  7.5.2 Pollution Probe Foundation 7-44
  7.5.3 INFORM 7-45
  7.5.4 Environmental Defense Fund 7-46
  7.5.5 German Marshall Fund 7-47
7.6 Summary 7-47

8. POTENTIAL STRATEGIES/OPTIONS FOR FURTHERING THE GOAL OF WASTE MINIMIZATION 8-1

8.1 Identification and Organization of Options 8-1
8.2 Potential Criteria for Deciding among Options 8-7
8.3 Reliance on Authorities and Requirements Defined by the Hazardous and Solid Waste Amendments of 1984 ... 8-8
8.4 The Scope of Applicability: Modification of Definition of Solid Waste and Associated Regulations .. 8-10
  8.4.1 Clarification of Relationship of Treatment and Reclamation 8-11
  8.4.2 Clarification of Relationship of Ingredient to Feedstock 8-12
  8.4.3 Greater Use of Concept of Equivalence in Determining Which Recycled Materials Should Be Subject to Regulation 8-13
8.5 Performance Standards 8-15
  8.5.1 Performance Standards Limiting Volume and/or Toxicity of Wastes for Generators 8-15
  8.5.2 Waste Generation Marketable Permit Program 8-18
  8.5.3 Prohibit or Restrict Generation of Specific Wastes 8-22

Page No.

8.5.4 Use of Effluent Guidelines to Increase Source Reduction and Recycling (CWA) 8-23
8.5.5 Establishment of Toxicity Levels for Delisting Petitions 8-24
8.6 Management Practices 8-25
8.6.1 Require Information from Generators on Material Inputs, Uses, and Discharges 8-25
8.6.2 Use of Permits to Limit Amount of Waste That Can Be Land Disposed, Incinerated, or Otherwise Disposed of or Treated per Generator . 8-28
8.6.3 Require Segregated Waste Streams for Potentially Recyclable Wastes 8-30
8.6.4 Require Technical Audits to Identify Waste Reduction Potential 8-33
8.6.5 Ban the Landfilling, Treatment, or Incineration of Potentially Recyclable Wastes 8-34
8.7 Economic Incentives 8-35
8.7.1 Development of Information and Technology Transfer Network 8-35
8.7.2 Establish Preferred Procurement Practices 8-40
8.7.3 Develop Improved Waste Marketing Capability for Hazardous Wastes of the Military Services 8-46
8.7.4 Non-Tax Financial Incentives 8-48
8.7.5 Tax Incentives 8-49
8.7.6 Waste-End tax 8-52
8.7.7 Rating Outstanding Recycling Facility Performance 8-55
8.7.8 Reduced Liability for Generators Using Specially Permitted Recyclers 8-57
8.7.9 Recycling Substances Act 8-59
8.7.10 Expedited Consideration of Delisting Petition 8-61
8.7.11 Enforcement Bounties 8-61

9. ANALYSIS OF FINDINGS 9-1

9.1 Trends in Waste Minimization 9-1
9.2 Nontechnical Factors That Promote and Inhibit Waste Minimization 9-4
9.3 Governmental Efforts to Promote Waste Minimization 9-9
9.4 Options to Further Promote Waste Minimization 9-11

TABLE OF CONTENTS (continued)

Page No.

10. REFERENCES 10-1

VOLUME 2

APPENDIX A DATA BASES USED IN THIS STUDY
APPENDIX B PROCESS STUDIES

VOLUME 3

APPENDIX C RECYCLING TECHNOLOGIES AND PRACTICES

APPENDIX D NORTHEAST INDUSTRIAL WASTE EXCHANGE'S ON-LINE COMPUTER SYSTEM

APPENDIX E CONDUCTING A PROJECT PROFITABILITY ANALYSIS

APPENDIX F EPA'S DEFINITION OF SOLID WASTE

APPENDIX G CORRESPONDENCE FROM EPA ON WASTE MINIMIZATION ACTIVITIES

APPENDIX H COMPILATION OF INDUSTRIAL WASTE REDUCTION CASES

APPENDIX I ENVIRONMENTAL AUDITING POLICY STATEMENTS

APPENDIX J DESCRIPTIONS OF STATE PROGRAMS

APPENDIX K TWO PROPOSED REGULATIONS ON HAZARDOUS WASTE MANAGEMENT BY TWO COUNTIES IN CALIFORNIA

LIST OF TABLES

Page No.

Table 2-1 Waste Generation: A Summary of Process Origins, Causes, and Controlling Factors 2-3

Table 2-2 Typical Motivational Aspects Related to Waste Generation or Minimization 2-5

Table 2-3 Industry Ranking by Hazardous Waste Generation Using 2-Digit SIC Code 2-8

Table 2-4 Industry Ranking by Hazardous Waste Generation Using 4-Digit SIC Code 2-10

Table 2-5 SIC Classification of Small Quantity Generators by Industrial Groups Targeted by the National Small Quantity Generator Survey 2-13

Table 2-6 Profile of RCRA Characteristic Waste Generation by the Ten Highest Volume Wastes Generating Industries in 1981 2-17

Table 2-7 List of Major Products Based on Nationwide Total Waste Generation Rates 2-32

Table 2-8 List of Major Products Based on Nationwide Hazardous Waste Generation Rates 2-33

Table 2-9 List of Major Products Based on Specific Total Waste Generation Rates (lb Total Waste/lb Product) 2-34

Table 2-10 List of Major Products Based on Specific Hazardous Waste Generation Rate (lb Total Waste/lb Product) 2-35

Table 3-1 Current and Future Reduction Indices for All Wastes Considered in Process and Practice Studies 3-15

Table 3-2 Current and Future Reduction Indices for "F" and "K" RCRA Wastes Considered in Process and Practice Studies 3-18

Table 3-3 National Hazardous Waste Generation and Reduction Profile 3-20

Table 3-4 Summary of Identified Product Substitutions 3-24

Table 4-1 Ten Highest Volume Waste Generating Industries – Generation and Recycling Volumes During 1981 4-5

Table 4-2 Wastes Recycled During 1981 4-10

Table 4-3 F- and K-Code Wastes Unlikely to Be Recycled in Significant Volumes 4-23

Table 4-4 Ranges of Costs for Technologies Used for Recovery and Recycling of Solvents 4-26

Table 4-5 Ranges of Costs for Technologies Used for Recovery and Recycling of Metals 4-34

Table 4-6 List of Information and Material Waste Exchanges 4-47

Table 5-1 Costs Associated with Hazardous Waste Generation 5-8

Table 5-2 Treatment Processes Identified 5-17

Table 5-3 Factors That Influence Cleanup Costs of a Hazardous Waste Site 5-19

Table 5-4 Average Estimated Cleanup Cost by Type of Site 5-21

Table 5-5 Waste Materials Defined as Solid Wastes under the Revised Definition 5-44

Table 5-6 Timetable of Land Disposal Restrictions 5-50

Table 5-7 Solvent- and Dioxin-Containing Hazardous Wastes for Which Land Disposal Restrictions Were Proposed by EPA 5-52

Table 6-1 Characterization of Reported Waste Minimization Techniques 6-3

Table 6-2 Characterization of Reported Efficiency 6-5

Table 6-3 Capital Cost Outlays 6-5

Table 6-4 Annual Cost Savings 6-7

Table 6-5 Payback Periods 6-7

Table 7-1 State Regulatory Programs and Final Authorization Status as of December 9, 1985 7-21

Table 7-2 Fee and Tax Incentives to Minimize Waste for Hazardous Waste Generators and/or Disposers 7-31

Table 7-3 Information Programs That Promote Hazardous Waste Minimization 7-39

Table 8-1 Categories of Waste Management Options and Their Relationship to Federal and State Programs 8-5

[illegible]

Page No.

Figure 2-1 Distribution of the Total Volume of Hazardous Waste Generated by SIC Category 2-9

Figure 2-2 Management Practices of the Chemical and Allied Products Industries (SIC 28) for Waste Streams Containing Nonhalogenated Solvents 2-20

Figure 2-3 Management Practices of the Chemical and Allied Products Industries (SIC 28) for Waste Streams Containing Halogenated Solvents 2-21

Figure 2-4 Management Practices of the Chemical and Allied Products Industries (SIC 28) for Waste Streams Containing Halogenated (Nonsolvent) Organic Wastes 2-24

Figure 2-5 Management Practices of the Chemical and Allied Products Indistries (SIC 28) for Metal-Bearing Waste Streams 2-26

Figure 2-6 Management Practices of the Chemical and Allied Products Industries (SIC 28) for Waste Streams Containing Corrosive Wastes 2-28

Figure 2-7 Management Practices of the Chemical and Allied Products Industries (SIC 28) for Waste Streams Containing Cyanide/Reactive Wastes 2-30

Figure 3-1 Elements of Waste Minimization 3-3

Figure 4-1 Comparison of Volume Generated and Volume Recycled in 1981 by the Ten Highest Hazardous Waste Generating Industries 4-6

Figure 4-2 Distribution of the Total Volume of Hazardous Waste Recycled During 1981, by SIC Category 4-8

Figure 4-3 Weighted Average Concentrations of Constituents in Waste Streams Recovered or Reused by the Chemical and Allied Products Industries (SIC 28) 4-15

LIST OF FIGURES (continued)

Page No.

Figure 4-4 Weighted Average Concentration of Nonhalogenated Solvent Wastes Handled by Various Management Practices in the Chemical and Allied Products Industries (SIC 28) 4-16

Figure 4-5 Weighted Average Concentration of Halogenated Solvent Wastes Handled by Various Management Practices in the Chemical and Allied Products Industries (SIC 28) 4-17

Figure 4-6 Weighted Average Concentration of Metal Wastes Handled by Various Management Practices in the Chemical and Allied Products Industries (SIC 28) 4-18

Figure 4-7 Weighted Average Concentration of Halogenated (Nonsolvent) Organic Wastes for Various Management Practices in the Chemical and Allied Products Industries (SIC 28) 4-19

Figure 4-8 Weighted Average Concentration of Corrosive Wastes Handled by Various Management Practices in the Chemical and Allied Products Industries (SIC 28) 4-20

Figure 4-9 Weighted Average Concentration of Cyanide/Reactive Wastes Handled by Various Management Practices in the Chemical and Allied Products Industries (SIC 28) 4-21

Figure 5-1 Organizational Structure for a Typical Corporate Environmental Program 5-28

EXECUTIVE SUMMARY

The Hazardous and Solid Waste Amendments of 1984 (HSWA) establish as a goal and national policy the minimization of hazardous waste generation and its subsequent land disposal. The achievement of this objective will require a strategy to reduce, whenever practical, the amount of hazardous waste generated, treated, stored, or disposed of. Both current and potential efforts for minimizing hazardous waste are the subject of this study.

This study originates from the directive in HSWA that EPA prepare a Report to Congress by October 1986 on waste minimization. The Report to Congress must address the feasibility and desirability of establishing standards of performance, required management practices, or other actions to ensure that hazardous wastes are managed in ways that minimize present and future risks to human health and the environment.

Definition and Scope of Waste Minimization

Formal definitions of "waste minimization" and "source reduction" have not as yet been issued by EPA. Based on information contained in the legislative history of the Hazardous and Solid Waste Amendments (HSWA) of 1984, on discussions with EPA personnel, and on the language of HSWA itself concerning waste minimization, the following working definitions have been used for the purposes of developing this Report to Congress:

Waste minimization:	The reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored, or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of hazardous waste or (2) the reduction of toxicity of hazardous waste, or both, so long as such reduction is consistent with the goal of minimizing present and future threats to human health and the environment.
Source reduction:	Any activity or treatment that reduces or eliminates the generation of a hazardous waste within a process.

"Recycling" is considered to be a generic term that encompasses both reuse and reclamation as they are defined in EPA's revised definition of "solid waste" published in the January 4, 1985 Federal Register.* These definitions are as follows:

Recycled:	A material is "recycled" if it is used, reused, or reclaimed (40 CFR 261.1(c)(7)).
Used or reused:	A material is "used or reused" if it is either (1) employed as an ingredient (including its use as an intermediate) in an industrial process to make a product; however, a material will not satisfy this condition if distinct components of the material are recovered as separate end products (as when metals are recovered from metal-containing secondary materials), or (2) employed in a particular function or application as an effective substitute for a commercial product (40 CFR 261.1(c)(5)).
Reclaimed:	A material is "reclaimed" if it is processed to recover a usable product or if it is regenerated. Examples are recovery of lead values for spent batteries and regeneration of spent solvents (40 CFR 261.1(c)(4)).

In the broadest sense, HSWA regard waste minimization as any action taken to reduce the volume or toxicity of wastes. Thus, waste minimization also includes the concept of waste treatment, which encompasses such technologies as incineration, chemical detoxification, biological treatments, and others. The Agency has already embarked on a broad program for waste treatment; thus, this report focuses on source reduction and recycling, the two aspects of waste minimization where basic policy options still remain open.

Overall Study Approach

During this study, information was gathered and analyzed concerning trends in hazardous waste generation and the methods used for waste minimization. The information was used to characterize recycling and waste generation trends with respect to specific industries, waste volumes, and waste types and to select certain industries and processes in order to study their existing and potential source reduction practices.

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* This study also addresses the practice of burning for energy recovery as a form of recycling. For consistency with EPA regulations, it is assumed that such burning recovers a minimum of 60 percent thermal energy, of which 75 percent is used, in order to qualify as recycling.

Recycling issues were examined with respect to the following five generic hazardous waste stream categories: (1) solvents, (2) halogenated organics other than solvents, (3) metals, (4) corrosives, and (5) cyanides and other reactives. The approach used for recycling is not industry-specific. It is believed that, in general, the recycling technologies available are independent of the specific industrial processes that produce the waste.

Source reduction issues, unlike recycling, were examined on an industry-specific basis. Technology modifications, process changes, and product substitution, all aspects of source reduction, are associated with a particular process or industry, as opposed to a particular type of waste stream.

For both recycling and source reduction, trends or general patterns of such practices among U.S. industries were identified. Also examined were the following issues as they affect a company's decision to adopt waste minimization practices: (1) economic, (2) regulatory, (3) technological, (4) liability, and (5) attitudinal/organizational.

Key Findings

Causes of Waste Generation

In general, industrial waste is generated because less than 100 percent of the combined mass of all material input streams into a production process leaves such process as a final product. There are two types of raw input materials: principal and auxiliary. The principal raw materials are directly converted into the final product. For example, propylene and chlorine are the principal raw materials for the synthesis of allyl chloride. The auxiliary raw materials are not converted into a final product, but are necessary to enhance product quality or to operate a process.

Examples of auxiliary raw materials include solvents used for parts cleaning, water for washing operations, lime for water treatment, catalysts for reactions, and other similar operations.

In the case of principal raw materials, waste generation is directly dependent on the product yield. The higher the yield, the less waste is produced as a result of incomplete conversion, undesirable byproduct formation, or inefficient operation or design of separation equipment used to purify the product. Hence, waste minimization efforts are, in this case, indistinguishable from efforts to improve product yield. Such efforts are generally focused on improvement of catalysts, input material purity, process design, and operational controls.

In the case of auxiliary raw materials, waste generation is often related to the type and amount of impurities to be removed, level of energy and water use, type of material used, process and equipment design, and operational controls. Material conservation and loss control efforts through source reduction and recycling are of prime importance. The often-used example of reclamation and reuse of cleaning solvents provides an illustration of auxiliary material conservation.

Trends in Waste Minimization

The level of waste generation in terms of units of waste per unit of product appears to have declined significantly in the last 10 to 15 years. This decline is attributed to implementation of a specific list of source control techniques and four industry-wide practices identified by EPA's study of 18 processes. EPA believes, based on the literature descriptions of the practices that the 10-15 year timeframe is when most of the source reduction techniques actually have been applied. Therefore, it is estimated that if none of these techniques were in place today, industry could be generating up to twice the waste per unit production than it does at present. (It must be noted that this estimate is an approximate rather than a definitive representation of the current extent of source reduction practices to date.)

The likelihood of future reductions of waste generation appears to be significant. When expressed in terms of unit waste per unit product, estimates suggest future reductions of 15 to 30 percent compared to the current rate of waste generation. These reductions would result from the extension of existing source control techniques and the application of new technologies to their full rated potential. Again, these estimates are approximate and involve extensive use of qualitative data by the Agency.

Of the total of hazardous waste generated in 1981, approximately 4 percent was recycled, according to information derived largely from an EPA survey. Of the 4 percent of industrial waste recycled in 1981, the largest volumes of wastes recycled were chromium-bearing plating solutions and electroplating wastewater, whose constituents were reused within the generating process. Such use represents a cost savings to the generator both in raw materials and in disposal costs. Generators recycling plating solutions and wastes include the Transportation Equipment industry (SIC 37) and the Primary Metals industry (SIC 33). Other wastes commonly recycled include spent halogenated and nonhalogenated solvents (various industries), slop oil emulsions and other wastes from petroleum refining (SIC 29), and emission control dusts and sludges from production of steel and lead smelting (SIC 33).

Future recycling will include an expanded role for commercial recyclers, transfers of bulk waste among large industries, and central recovery facilities. State-of-the-art treatment and recycling technologies include mobile treatment units that can be set up temporarily or permanently at generators' facilities by a commercial waste management company. Other case studies document the cooperative efforts of generators in pooling or trading their wastes in order to share costs and minimize liabilities.

Market demand is a critical factor for a company deciding whether or not to reclaim materials that cannot be used in their manufacturing process. Economics will seldom support recovering materials with limited demand.

Factors Affecting the Decision to Minimize Waste

Economics. *The principal guiding mechanism in most decisions to implement waste minimization practices is one of economics*. Evaluations of technological feasibility are directly related to economic viability of the source reduction or recycling technology. In the majority of cases documenting either of these practices, the cost savings appear to justify the investment in equipment, services, methods, or techniques. The possibility of increased costs of land disposal resulting from increased technological requirements for land disposal units may also act as an economic incentive to reduce wastes.

Where waste minimization practices are *not* adopted, economic factors are frequently cited as the principal reasons. Economic impediments to waste minimization include:

- Real (as opposed to perceived) absence of economic feasibility for the options considered to minimize waste or maximize yield;
- Absence of funds to evaluate waste minimization options; and
- Lack of capital to implement waste minimization measures with proven feasibility (e.g., because economic benefits of waste minimization may appear minor in comparison to other projects competing for limited investment capital).

Regulatory Factors. *Regulations may promote waste minimization by limiting the choices of waste management and by changing the relative economics of waste disposal practices*. In particular, regulations resulting from HSWA may present a powerful incentive for voluntary waste minimization. Reasons include:

- Technological and other requirements imposed by HSWA on all new and existing TSD facilities may lead to an increase in the cost of land disposal and an increase in closures of land disposal facilities; thus, generators are more likely to consider waste minimization practices.
- Generators must now certify on their hazardous waste manifests that they have a waste minimization program in place, to the extent economically practical. Generators must also include descriptions of their waste

minimization efforts in the biennial report. Further, TSD permits issued now contain a condition that the permittee certify annually that a waste minimization program is in place.

- Some companies who now may consider waste minimization might never have done so were it not for these recent legislative and regulatory developments. Other companies, for whom waste minimization was a result of increasing product yield, may now give primary consideration to such practices in light of the land disposal restrictions and limited waste management alternatives.

Although HSWA regulations may provide direct incentives for waste minimization, there are aspects to other regulatory programs that may inhibit it. These include:

- Members of the regulated community frequently cite the RCRA permitting process as slow, unpredictable, and costly. Some companies fear that the installation of new equipment associated with source reduction may require permitting as a treatment facility under the RCRA regulations, and, therefore, these companies consider other waste management alternatives more economical.

- The definition of "solid waste" was revised recently to ensure adequate protection of human health and the environment. EPA's recently revised definition results in some previously exempt wastes having to be manifested when shipped offsite for recycling. Some companies who do so fear that they could be held liable for damages caused by subsequent handling of the waste. Other companies within the regulated community perceive the regulation to require permitting if reclamation is practiced onsite. Although some onsite treatment technologies will require permitting, reclamation activities are exempt from such requirement; misinterpretation of the regulation may result in waste management decisions that are based on mistaken economics and that are actually counter to regulatory intentions.

- The problems associated with the siting of a waste treatment facility are significant obstacles to expanding treatment and resource recovery capacity.

- The corrective action requirements imposed by HSWA may also present an obstacle in the permitting of TSD facilities. Specifically, HSWA require that owners of all new TSDs must take corrective actions for releases of hazardous waste (or constituents) from any solid waste management unit on the property. This requirement applies regardless of when the waste was placed in the unit, or whether the unit is closed.

- The liability provisions of CERCLA and the liability insurance shortage may inhibit offsite recycling. Under CERCLA Sections 106 and 107, a generator can be held financially responsible for the entire cleanup or restoration of a facility to which it has sent wastes. Although an incentive for both source reduction and onsite recycling (discussed below), it also presents a problem for companies lacking in-house expertise and resources. Such companies are more likely to use offsite recyclers. These generators desire to obtain liability insurance to protect themselves from third party and government claims for damages resulting from environmental releases of hazardous substances. The cost of all forms of commercial liability insurance, however, has risen sharply over the past several years, while its availability has been sharply reduced.

Liability Issues. The issue of liability may inhibit offsite recycling, but may also promote onsite waste minimization practices. Generators of hazardous waste can be held liable and made to pay for damages resulting from the subsequent mishandling of their wastes under the CERCLA statute. A generator's liability in shipping hazardous wastes offsite for recycling is therefore dependent on the reliability of the recycler. Some small generators, in particular those who lack the in-house expertise to recycle onsite, may decide that they have no acceptable recycling alternative than to ship offsite. This situation, combined with increased restrictions on land disposal and increasing costs, may lead to incidents of illegal disposal. For companies in a position to practice onsite recycling, however, the combination of new regulatory requirements with potential liability may serve as an effective incentive to recycle, as well as to enlist source reduction practices.

Increased transportation costs of hazardous wastes caused by liability concerns may inhibit use of recycled materials. Because transporters of hazardous wastes face greater potential liability than transporters of virgin materials, the transporters may charge more for the shipping of wastes than for virgin materials. Costs of waste materials for reclamation and reuse may be higher than using virgin materials because of these higher transportation costs. Faced with a choice between reclaiming a material for reuse in a process and using virgin materials, companies may choose the latter under some circumstances, if the virgin material is more economical than reclaiming and reusing the waste material shipped offsite.

Attitude/Organizational Issues. The organization of a company and its attitude toward waste minimization are also significant factors that both promote and inhibit its practice. Problems may arise in larger companies when environmental managers do not effectively communicate or interact with their production-oriented counterparts or those responsible for research and development. Engineers responsible for production operations may not be fully cognizant of hazardous waste handling and disposal problems. Effective communication of a corporate waste reduction policy to all operations levels contributes to the implementation of a successful waste reduction program. It is often helpful for a new process or method to be promoted by a high-ranking individual who is actively committed to waste reduction.

The effect of habit on industrial design and management practices may inhibit the creation of waste minimization programs. Familiarity with production techniques gives rise to operational efficiencies. Thus, management may be satisfied with production operations as they stand, even if large quantities of waste are generated, and may be reluctant to try innovative techniques (the "if it isn't broke, don't fix it" outlook). This outlook may inhibit the development of initiative among managers to take waste reduction measures.

Government Efforts to Promote Waste Minimization

Many State and Federal agencies are undertaking programs that either directly or indirectly promote waste minimization and that may mitigate conflicts caused by regulations that both promote and inhibit waste minimization. Examples of State programs include the following:

- General information programs in which waste minimization information is disseminated through publications and conferences;
- Technical assistance programs that provide generators with specific technical advice on how their processes could be altered to reduce waste generation;

- Waste exchange programs, which facilitate recycling by helping companies to "match" the wastes they have available with those that other companies can use; and

- Grants, awards, loans, and bonds provided to companies instituting source reduction or recycling technologies

The fee and tax systems of some States are structured to provide incentives to minimize waste. In some States, generators are assessed on the basis of amounts of wastes disposed of. This tax, called a "waste-end" tax, is levied primarily as a means to generate revenue and to make land disposal the least preferred alternative. Other systems grant tax credits for investment in source reduction and recycling equipment.

Federal agencies also have initiated programs concerned with waste minimization. Research and development on waste minimization is being conducted by EPA, the Department of Energy, and the Bureau of Mines, as well as by Congressional agencies such as the Office of Technology Assessment (OTA) and the Congressional Budget Office (CBO). OTA is conducting a study on source reduction that will examine State and Federal activities and provide policy options on the types of programs the Federal Government can implement to enhance source reduction. CBO has completed a study that examined different types of "waste-end" tax systems as a method for encouraging waste reduction. In still another example, the Tennessee Valley Authority (TVA) receives $1.5 million in Federal appropriations per year for implementation of a program to reduce waste generation, improve waste collection and transportation techniques, and enhance waste utilization in the public and private sectors.

The Department of Defense (DOD), as a generator of hazardous waste, is involved in waste minimization at both the research and implementation levels and its practices may serve as a model for generators in the private sector. DOD has made it a policy since 1980 to limit the generation of hazardous waste through alternative procurement policies and operational procedures. DOD implements waste minimization activities through the Defense Environmental Leadership Project, the Defense Logistics Agency, and the efforts of the individual bases or installations themselves. Recently, the Joint Logistics Chiefs (JLC) of the services developed a waste minimization strategy and has proposed it for adoption throughout DOD. The program would include a review of procedures and equipment, increased research and development, and an inter-service information exchange/technology transfer. Because DOD's activities parallel many in the private sector (e.g., painting, plating, metal fabrication), its efforts may influence practices in industry, particularly where cost savings are demonstrated.

Options to Promote Waste Minimization

As part of the study, 23 options for encouraging waste minimization are identified. The options are based, in some cases, on programs that are actually in place, and in others, on new concepts or approaches that were developed in the course of the study. Among the options described are regulatory programs, nonregulatory programs, and legislative changes. The options include performance standards, management practices, and a broad array of economic incentives.

Summary of Findings

Until recently, waste minimization was undertaken primarily for purposes other than for reducing wastes. Waste minimization was an incidental result of efforts to decrease manufacturing costs through improvement of yields and operating efficiency. With the requirements of RCRA and the recent passage of HSWA, however, companies have begun to consider such practices as a means to reduce wastes, liabilities, and the costs associated with regulation.

Despite the factors that may promote waste minimization, some barriers to its practice exist. These are mainly due to economic difficulties in investing in waste minimization technologies, economic/financial difficulties caused by regulatory requirements, real or perceived problems in complying with regulations associated with implementing waste minimization practices, technological barriers, fear of changing the product and/or its quality, and lack of in-house expertise to implement available technologies.

The development of certain State and Federal programs may alleviate impediments to waste minimization. Because of the increased interest in waste minimization brought about by HSWA, information programs may be particularly helpful in clearing up misinterpretations of regulations. Some companies will benefit from assistance and education to personnel. Innovative financial incentives also may encourage growth in waste minimization practices.

The options described in this study for promoting waste minimization may also offer some resolution of conflicts between factors that promote and inhibit waste minimization. The degree to which HSWA by itself effects an increase in waste minimization probably will not be evident for several years. Such information will be significant in determining whether additional performance standards or management practices are desirable.

PREFACE

The Solid Waste Disposal Act, as amended by the Hazardous and Solid Waste Amendments of 1984 (HSWA), establishes as an objective the minimization of both the generation and land disposal of hazardous waste. It also establishes as a national policy that hazardous waste generation is (where practical) to be reduced or eliminated as expeditiously as possible (Sections 1003(a)(6) and 1003(b)). These amendments require generators (except small-quantity generators) to certify on their manifests that (1) they have a program in place to minimize the amount and toxicity of wastes generated to the extent economically feasible, and (2) the proposed treatment, storage, or disposal method minimizes the present and future threats to human health and the environment. This certification must also be made annually by holders of Treatment, Storage, and Disposal (TSD) permits (issued after September 1, 1985). In addition, generators must include in their biennial reports (1) a description of the efforts undertaken to reduce volume and toxicity of waste generated, and (2) a description of the changes achieved in volume and toxicity of waste.

HSWA also requires that the U.S. Environmental Protection Agency (EPA) prepare a Report to Congress by October 1986 that addresses the "feasibility and desirability" of (1) establishing standards of performance or of actions under the Solid Waste Disposal Act that require generators to minimize waste, and (2) establishing management practices or other requirements so that wastes are managed in ways that minimize present and future risks to human health and the environment. The report must also include recommendations that EPA determines are "feasible and desirable" to implement the national policy mentioned above (Section 8002(r) of the Solid Waste Disposal Act, as amended by HSWA). This study originates from the directive in HSWA that EPA prepare a Report to Congress.

Report Objectives

The primary objectives of this report are threefold:

- To identify waste minimization practices in the United States by major industry processes and by major waste stream;

- To identify factors that promote and inhibit the adoption of waste minimization practices by industry; and

- To identify strategies by which waste minimization can be increased.

The report will also serve as a resource document on waste minimization for Federal and State programs, industries, and the general public. It must be noted that this study approaches the objectives stated above in an exploratory manner because of the size, diversity, and complexity of the subject area. The results, therefore, must necessarily be viewed as exploratory rather than definitive representations of the waste minimization issue.

Report Organization

The report has been organized in accordance with the three objectives stated above. "Waste Minimization," as it is used in this study, is defined and explained in Section 1. Strategies (via performance standards, management practices, or other actions) are discussed in Section 8 and are based to a large degree on efforts already in practice by industry and by government agencies; those efforts are described in Sections 6 and 7, respectively. Information on hazardous waste generation and the methods used to minimize it are then presented in the next three sections of the report (Sections 2 through 4). Factors that promote or inhibit waste minimization are examined in Section 5. More detailed information on various technical and regulatory aspects of this study is presented separately in the appropriate appendices in Volumes 2 and 3.

Data Sources

The information contained in this report was compiled from a variety of sources including the 1981 Regulatory Impact Analysis (RIA) Mail Survey, 1983 Biennial Report Data Base, 1983 Industrial Studies Data Base, 1984 National Small Quantity Generator Hazardous Waste Survey, State information, effluent guidelines background documents, and other literature. Appendix A contains descriptions of the various data sources, how they were used, the deficiencies or gaps associated with them, and the extent to which these deficiencies can be rectified.

1. DEFINITION AND SCOPE OF WASTE MINIMIZATION

Formal definitions of "waste minimization" and "source reduction" have not as yet been issued by EPA. Based on information contained in the legislative history of HSWA, on discussions with EPA personnel, and on the language of HSWA itself concerning waste minimization, we have drafted the following working definitions for purposes of this study:

• Waste minimization:	The reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored, or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of hazardous waste, or (2) the reduction of toxicity of hazardous waste, or both, so long as such reduction is consistent with the goal of minimizing present and future threats to human health and the environment.
• Reduction of total volume or quantity:	The reduction in the total amount of hazardous waste generated, treated, stored, or disposed of as defined by volume, weight, mass, or some other appropriate measure.
• Reduction in toxicity:	The reduction or elimination of the toxicity of a hazardous waste by (1) altering the toxic constituent(s) of the waste to less toxic or nontoxic form(s) or (2) lowering the concentration of toxic constituent(s) in the waste by means other than dilution.
• Source reduction:	Any activity or treatment that reduces or eliminates the generation of a hazardous waste within a process.
• Source control:	Any activity or treatment classifiable under source reduction with the notable exception of product substitution.
• Product substitution:	The replacement of any product intended for an intermediate or final use with another product intended and suitable for the same intermediate or final use.

As the definition of source reduction indicates, this study examines treatment of hazardous wastes if it is a part of the production process, as opposed to treatment that occurs offsite. This is explored in further detail in Section 1.2. Although the definition refers to reduction or elimination of the generation of a hazardous waste, this study also examines the generation and reduction of wastes that may not be regulated under RCRA. Wastes that are not regulated under RCRA are included in the study to the extent that the reduction of such wastes may result in a reduction of hazardous wastes that are regulated. For example, in certain instances, the reduction of a wastewater that is exempt from RCRA regulation may involve a process change that results in an accompanying reduction in hazardous waste. Furthermore, reduction of wastewater may result in reduction of waste from the subsequent treatment of the wastewater; these sludges are regulated under RCRA. This approach recognizes that waste minimization is a function of more than one environmental medium. A reduction in air pollutants or wastewater may also affect the generation of solid and hazardous wastes. Thus, it is necessary to examine all components of a process.

For purposes of this study, "recycling" is considered to be a generic term that encompasses both reuse and reclamation as they are defined in EPA's revised definition of "solid waste" published in the January 4, 1985, Federal Register. These definitions are as follows:

- Recycled: A material is "recycled" if it is used, reused, or reclaimed (40 CFR 261.1(c)(7)).
- Used or reused: A material is "used or reused" if it is either (1) employed as an ingredient (including use as an intermediate) in an industrial process to make a product (for example, distillation bottoms from one process used as feedstock in another process). However, a material will not satisfy this condition if distinct components of the material are recovered as separate end products (as when metals are recovered from metal-containing secondary materials), or (2) employed in a particular function or application as an effective substitute for a commercial product (for example, spent pickle liquor used as phosphorus precipitant and sludge conditioner in wastewater treatment) (40 CFR 261.1(c)(5)).

- Reclaimed: A material is "reclaimed" if it is processed to recover a usable product or if it is regenerated. Examples are recovery of lead values from spent batteries and regeneration of spent solvents (40 CFR 261.1(c)(4)).

This study addresses burning for energy recovery as a form of recycling, assuming that such burning recovers a minimum of 60 percent of the recoverable thermal energy, and that 75 percent of that recovered energy is actually used. This is discussed in further detail in Section 1.2.

1.1 Background and Scope of the "Waste Minimization" Definition

Although no formal definition of waste minimization is provided, HSWA and its legislative history make clear that the term includes both source reduction and recycling. In particular, Section 1003(a)(6) of the Solid Waste Disposal Act (as amended by HSWA) states that one of the objectives of the Act is to minimize "...the generation of hazardous waste and the land disposal of hazardous waste by encouraging process substitution, materials recovery, properly conducted recycling and reuse, and treatment." Other indications of what may qualify as waste minimization appear in the HSWA requirements for generators regarding the certification, which must appear on the manifest. The certification must state that "...the generator of the hazardous waste has a program in place to reduce the volume or quantity and toxicity of such waste to the degree determined by the generator to be economically practicable." (EPA states in the preamble to its codification of these requirements that the generator, not EPA, is to make determinations of economically practicable and best method currently available (50 FR 28734). This is discussed further in Section 5.5.1.)

An examination of Senate Report 98-284 (p. 65) indicates that waste minimization involves a balancing between two concepts:

1. Hazardous waste is first to be reduced or eliminated as quickly as possible; and
2. The hazardous waste that is generated should be treated, stored, or disposed of in a manner to minimize the "present and future threat to human health and the environment."

Section 1003 of HSWA establishes the general national policy in favor of waste minimization and refers to the need to reduce the "volume or quantity and toxicity" of hazardous wastes. The Senate Report recognizes, however, that waste minimization does not always mean a reduction in volume of waste generated. For example, in some cases, a reduction in waste volume may result in increased toxicity, and in such instance, treatment, storage, or disposal methods may better address the present and future threat to human health and the environment (SR 98-284 pp. 66-67). On the other hand, waste concentration may be a useful waste minimization technique (e.g., in preparing materials for recycling). The key concept, however, is that waste minimization must be protective of human health and the environment.

In the broadest sense, the language of HSWA implies that waste minimization includes any action taken to reduce the volume or toxicity of wastes. Thus, waste minimization includes the concept of waste treatment, which encompasses such technologies as incineration, chemical detoxification, biological treatments, and others (Section 1003(a)(6)). EPA has already embarked on a broad program for waste treatment; thus, this report focuses on source reduction and recycling, the two aspects of waste minimization where basic options still remain open.

1.2 Background and Scope of the Issue of Burning for Energy as a Recycling Activity

This report includes burning for energy recovery as a recycling activity. Although EPA's definition of recycling does not specifically address burning, other portions of EPA's regulations indicate that in certain instances, burning for energy recovery is a recycling activity, even if it will be regulated in the future. In particular, 40 CFR 260.10 defines "Boiler," "Incinerator," and "Industrial Furnace." Also, 40 CFR 261.6 and 40 CFR 266 (Subparts D and E) address the burning of hazardous wastes for energy recovery in boilers and industrial furnaces. To fulfill the CFR definition of "boiler," devices must maintain a minimum amount of thermal energy recovery (60 percent), and must "export" at least 75 percent of this energy for actual use. The definition of "industrial furnace" also requires the recovery of materials or energy. If a combustion device meets neither of these criteria, it is defined as an "incinerator" by EPA and requires a permit under Subpart O of the RCRA regulations. For that reason, incineration activities are not considered to be recycling in this study.

References to such burning activities may, in some instances, include situations in which less than 60 percent energy recovery is achieved or in which less than 75 percent of recovered energy is actually used. This is because some of the case examples used may reflect a time when the above referenced definitions and regulations were not in effect. It is not always possible to ascertain from the literature the degree of heat recovery maintained. We have assumed, however, that future instances of burning for energy recovery will meet the requirements stated in the EPA regulations. In this study, a statement such as "solvent wastes are sometimes recycled by burning for energy recovery" thus is interpreted to mean we assume two things: (1) in the past, some solvent wastes may have been burned with some unspecified amount of energy recovered, and (2) in the future, solvent wastes burned for energy recovery will result in a minimum of 60 percent of thermal energy recovered, with 75 percent of this energy "exported" for actual use.

2. WASTE GENERATION PROFILE

This chapter presents a brief discussion of the causes of hazardous waste generation, including a listing of all industries and their share of waste production. A waste generation profile of the Chemicals and Allied Products Industry (SIC 28) is provided as an example to show major chemical processes and their respective shares in waste generation. Finally, a summary of other waste management practices is included.

2.1 Causes of Waste Generation

Industrial wastes are generated in chemical manufacturing and formulation processes, in refining of crude oil and processing of metals, and in the use and reclamation of processing solutions such as degreasing solvents and electroplating baths. Waste is generated in chemical manufacturing and formulation processes, because less than 100 percent of the raw materials mass entering a process is converted to final product. The attainment of complete conversion, or 100 percent yield, appears impossible, and should be viewed only as an asymptotic limit of all efforts to minimize waste or increase yields.

Historically, the problem of waste generation has been viewed as a question of yield maximization. While a significant effort has undoubtedly been undertaken to increase yield, with a corresponding decrease in waste generation (e.g., in the chemical process industry), the question of what constitutes an acceptable yield usually has been determined by comparison with the industry norm and the competition's economic performance. In certain cases, corporate management has assigned a low priority to the maximization of yield, especially if the costs of raw materials and waste disposal were low compared to the value added. This situation is typical for labor-intensive processes. In such cases, the prospect of realizing a marginal increase in profits by increasing yield (and lowering waste generation) is offset by the risk of detrimental impact on product quality, research expenditures, and other considerations.

Generation of other industrial wastes from processing solutions such as degreasing solvents and plating baths is not tied directly to the problem of yield maximization, because these materials are not converted into the final product. Organic solvents and inorganic solutions used in this way become wastes as the solutions become "spent." Waste is also generated from the residues of solvents and other solutions that are reclaimed by separation technologies such as distillation. Cost considerations for controlling generation of processing solution wastes may be similar to those for wastes from materials converted into final products.

How is waste generated? Typical industrial process waste origins, causes, and controlling factors are summarized in Table 2-1. Based on the 22 industrial process studies presented in Appendix B of this report, this information indicates that in a majority of cases, product and process design factors play a dominant role in waste generation. Thus, it can be concluded that design decisions affecting process, equipment, or product greatly influence subsequent waste generation. While operational aspects also are significant, they appear to be subordinate to the design aspects in their importance to waste generation.

Why is waste generated? Three categories of causes can be distinguished: economic, motivational, and regulatory.

Economic causes include:

- Real (as opposed to perceived) absence of economic feasibility for the options considered to minimize waste or maximize yield;
- Absence of funds to evaluate waste minimization options; and
- Lack of capital to implement waste minimization measures with proven feasibility (e.g., because economic benefits of waste minimization may appear minor in comparison with those of other projects competing for limited investment capital).

Motivational aspects related to waste generation (as opposed to minimization) are more difficult to characterize, since they stem from both individual and organizational attitudes, perceptions, biases, experiences, and political settings. Table 2-2 provides a summary and a brief description of the typical motivational aspects identified.

Table 2-1 Waste Generation: A Summary of Typical Process Waste Origins, Causes, and Controlling Factors

Waste origin	Typical causes	Operational factors	Design factors
Chemical reaction	• Incomplete reactant conversion • Byproduct formation • Spent catalyst - deactivation due to poisoning, sintering, etc. • Catalyst fines due to attrition	• Inadequate temperature control • Inadequate mixing • Poor feed flow control • Poor feed purity control	• Inadequate reactor design • Catalyst design or selection • Choice of process path • Choice of reaction conditions • Fast quench • Inadequate instrumentation or controls design • Poor heat transfer
Contact between aqueous and organic phases	• Vacuum production via steam jets • Presence of water as a reaction byproduct • Use of water for product rinse • Equipment cleaning • Cleaning of spills	• Indiscriminate use of water for cleaning or washing • Excessive clingage	• Choice of process route • Choice of auxiliary operations
Disposal of unusable materials	• Off-spec product generation caused by contamination, temperature/pressure excursions, reactants proportioning, inadequate precleaning of equipment, etc. • Obsolete material inventories	• Poor operator training and supervision • Inadequate quality control • Inadequate production planning and inventory control	• Inadequate automation • Inadequate degree of equipment dedication to a single process function

Table 2-1 (continued)

Waste origin	Typical causes	Operational factors	Design factors
Process equipment cleaning	• Presence of clingage • Deposit formation • Use of chemical cleaning agents	• Insufficient drainage prior to cleaning • Inadequate cooling water treatment • Excessive cooling water temperatures	• Oversized heat exchangers resulting in excessive film temperature and low fluid velocities • Consideration of on-stream cleaning with mechanical devices • Insufficient controls to prevent cooling water from overheating
Metal parts cleaning	• Disposal of spent solvent, cleaning sludge, or spent cleaning solution	• Indiscriminate use of solvents and water • Excessive dragout	• Choice between cold dip tank or vapor degreasing • Choice between solvent and aqueous cleaning solution
Metal surface treatment	• Dragout • Disposal of spent treatment solutions	• Poor rack maintenance • Indiscriminate rinsing with water • Too fast withdrawal of work piece	• Counter-current rinsing • Fog rinsing • Dragout collection tanks
Spills and leaks cleaning	• Spillage during manual material transfer operations • Leaking pump seals • Leaking flange gaskets	• Inadequate maintenance • Poor operator training • Lack of operator attention • Indiscriminate use of water in cleaning	• Choice of gasket material • Choice of seals • Use of welded or seal-welded construction • Plant layout

Table 2-2 Typical Motivational Aspects Related to Waste Generation or Minimization

Aspect/Cause	Origins/Underlying factors
Lack of awareness of benefits of waste minimization	• Poor availability of informaton • Lack of trained environmental staff • Low level of management involvement in operations/R&D/design
Lack of initiative to minimize waste	• Lack of competition (i.e., stable market share) • "If it isn't broke - don't fix it" attitude • Lack of mandate, policy, or leadership • Fear of upsetting product quality • Low priority ranking of waste minimization projects • Absence of company policy or mandate • Perception of poor economic/technical feasibility • Presence of adequate treatment/disposal systems
Negative attitude toward innovation	• "Can't be done" attitude, i.e., rejection of innovation because it is outside of habitual range of experience • Lack of adequate technical skills

Current perceived regulatory obstacles to waste minimization include the requirement to obtain a RCRA permit to install equipment that is viewed by EPA as part of the "treatment" technology. This requirement decreases the economic feasibility of recycling and may result in the landfilling of recyclable wastes. In other cases, there is a tradeoff between reducing waste by complying with one set of regulations that may, in turn, generate other regulated process waste streams. For example, compliance with stringent solvent air emission regulations for some processes results in installation of steam-regenerated carbon bed scrubbers, which produce a waste solvent that is often land disposed.

The above listing of the economic, motivational, and regulatory causes of waste generation is not complete; however, it does represent a brief summary of the typical factors. A more detailed discussion can be found in Section 5 of this report.

Finally, a different and broader perspective deserves to be mentioned. While the generation of hazardous waste, as discussed above, is taken from the point of view of a generator (i.e., "internal"), there is also an "external," or indirect, aspect, which is demonstrated by the following example. A company decides to replace certain existing electric motors with a newer, more efficient design, resulting in savings in electricity consumption. While this does not reduce the onsite waste generation, it does contribute to the reduction of water treatment waste at the power plant where the electricity used onsite is generated.

Numerous other examples can be cited to show that a decrease in product consumption stemming from conservation or some alteration of its use results in the overall reduction of waste generated in the chain of processes leading to that product's manufacture. From this broader perspective, product conservation efforts by consumers and efforts to produce more durable goods appear to be the principal controlling factors in waste minimization, or conversely, its generation.

2.2 Industry-Specific Waste Generation Profile

It was estimated that in 1983 U.S. industry generated 266 million metric tons of hazardous waste (CBO 1985). It is useful to determine which industries generate which portion of the total hazardous waste stream. To obtain such information, data from the 1981 RIA Mail Survey (Westat 1984) were analyzed and are presented in Table 2-3, along with data obtained by the Congressional Budget Office (CBO 1985).

As seen in Table 2-3, the Chemicals and Allied Products industry (SIC 28) ranks first in both compilations as the nation's leading generator of hazardous wastes. According to the more recent study (CBO 1985), which included some nonhazardous waste streams, the Primary Metals industry (SIC 33) ranks second and the Petroleum/Coal Products industry (SIC 29) third. The RIA Generator Survey data from 1981 indicate a higher ranking, by hazardous waste volume generated, for the Machinery, Except Electrical industry (SIC 35), the Transportation Equipment industry (SIC 37), and the Motor Freight Transportation and Warehousing industry (SIC 42). Figure 2-1 illustrates the distribution of hazardous waste generated during 1981 by specific SIC industries. The quantities (M gals) generated are given for each SIC code. To obtain a better level of resolution, another compilation of 1981 waste generation data was prepared using 4-digit SIC codes for waste-generating industries. It is presented in Table 2-4. Descriptions of each of the ten industries, in the 2-digit SIC categories, generating the largest volumes of hazardous waste during 1981 follow:

- Chemicals and Allied Products (SIC 28) - Facilities that either produce chemicals or use chemical processes to manufacture products from manufactured feedstocks. A wide range of industrial and consumer products is handled by this group including:
    - Acids, alkalies, salts, and organic chemicals;
    - Chemical intermediates to be formulated into synthetic fibers, plastics, materials, dry colors, and pigments;
    - Finished chemical products for use as materials or supplies in other industries such as paints, fertilizers, and explosives; and
    - Finished chemical products for ultimate consumption (e.g., cosmetics, drugs, and soaps).

  According to the most recent census data, there were 9,145 facilities categorized as SIC 28 in the United States in 1977 (U.S. Census of Manufacturers 1977).

Table 2-3 Industry Ranking by Hazardous Waste Generation Using 2-Digit SIC Code

Rank	Major industry	SIC code	Percent of total waste generated Source A (1983)	 Source B (1981)
1	Chemical & Allied Products	28	47.9	67.5
2	Primary Metals	33	18.0	2.4
3	Petroleum & Coal Products	29	11.8	3.1
4	Fabricated Metal Products	34	9.6	1.9
5	Rubber & Plastic Products	30	5.5	< 0.1
6	Miscellaneous Manufacturing	39	2.1	< 0.1
7	Nonelectrical Machinery	35	1.8	10.0
8	Transportation Equipment	37	1.1	5.6
9	Motor Freight Transportation	42	0.8	4.0
10	Electric & Electronic Machinery	36	0.7	1.6
11	Wood Preserving	24	0.7	< 0.1
12	Drum Reconditioning	50	< 0.1	< 0.1
	Total		100.0	98.0

Source: A Congressional Budget Office (CBO 1985).
B RIA Generator Survey Data Base.

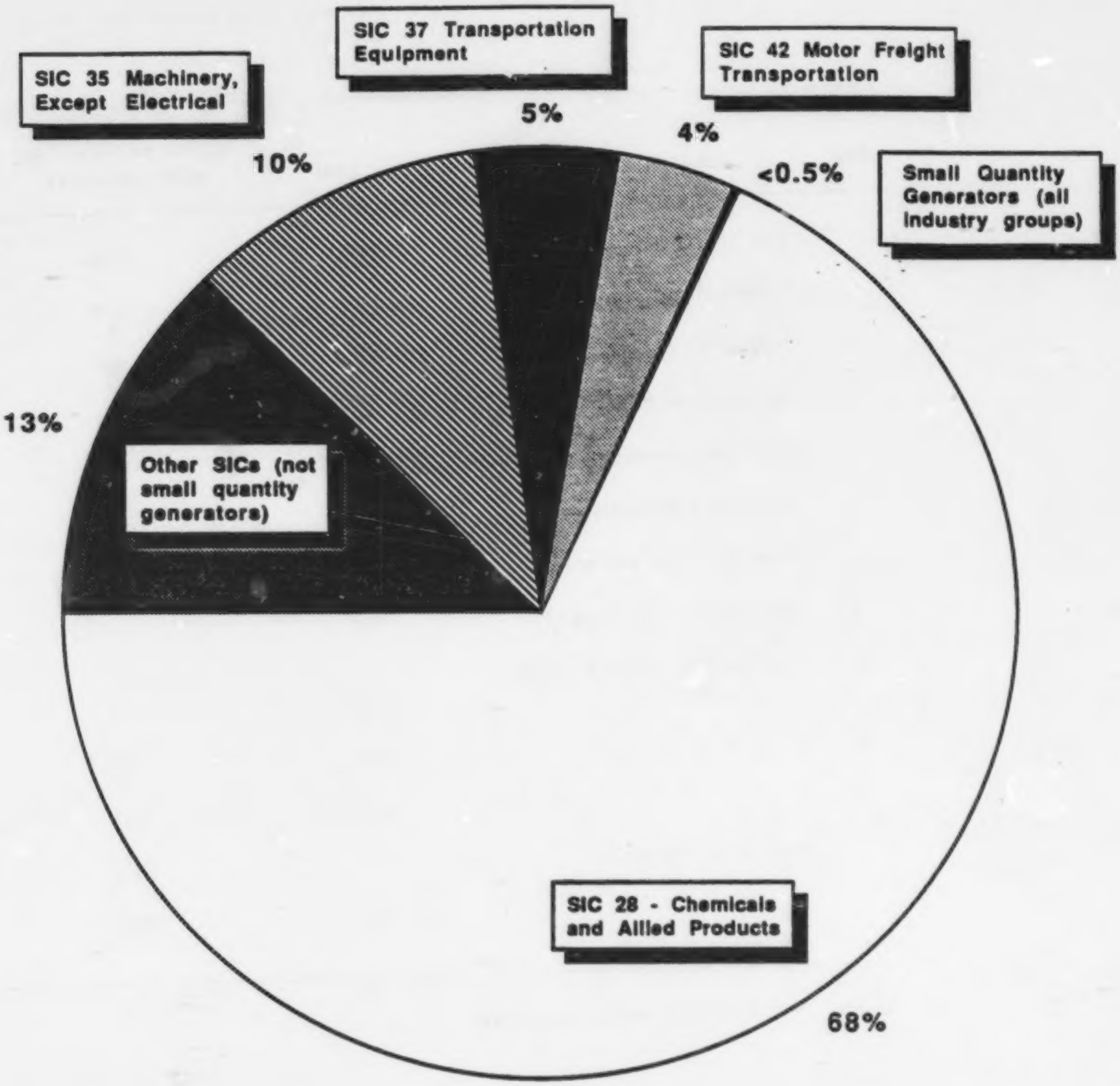

Figure 2-1 Distribution of the Total Volume* of Hazardous Waste Generated by SIC Category

Sources: RIA Generator Survey (1981 Data), Ruder et al. 1985. (1984 Data)
*Total Volume of Hazardous Waste Generated During 1981 = 42,000 M Gal

Table 2-4 Industry Ranking by Hazardous Waste Generation Using 4-Digit SIC Code

Rank	Industry	SIC Code	Percent of total 1981 waste generated
1	Cyclic Crudes & Intermediates	2865	37.0
2	Unidentified Chemical Products	2800	17.9
3	Industrial Organic Chemicals	2869	8.4
4	Construction Machinery	3531	5.0
5	Electronic Computing Equipment	3573	4.8
6	Trucking & Warehousing	4200	4.0
7	Transportation Equipment	3700	3.0
8	Petroleum & Coal Products	2900	2.8
9	Construction, Special Trade Contractors	1700	2.1
10	Alkalies & Chlorine	2812	1.8
		Subtotal	86.8
	Remaining Industries		13.2
		Total	100.0

Source: RIA Generator Survey Data Base.

- Machinery, Except Electrical (SIC 35) - Manufacture of machinery and equipment other than electrical and transportation equipment. Included are machines powered by built-in or detachable motors, and electric and pneumatic-powered portable tools. Excluded are electrical household appliances and hand tools (OMB 1972). There were 48,191 facilities in the SIC 35 category in 1977 (U.S. Census of Manufacturers 1977).

- Transportation Equipment (SIC 37) - Facilities manufacturing equipment for the transportation of passengers and cargo by land, air, and water. Important products of this industry include motor vehicles, aircraft, guided missiles and space vehicles, ships, boats, railroad equipment, motorcycles, bicycles, and snowmobiles (OMB 1972). There were 2,623 facilities in this industry in 1977 (U.S. Census of Manufacturers 1977).

- Motor Freight Transportation and Warehousing (SIC 42) - Local or long distance trucking, transfer services, or terminal facilities for handling freight, with or without maintenance facilities; also includes facilities for storage of farm products, furniture, other household goods, or commercial goods of any nature. Excludes facilities for the storage of natural gas (SIC 4922) and field warehousing (SIC 7399) (OMB 1972). There were 34,033 facilities in this industry category in 1977 (U.S. Census of Manufacturers 1977).

- Petroleum Refining and Related Industries (SIC 29) - Facilities primarily engaged in petroleum refining, manufacturing of paving and roofing materials, and compounding of lubricating oils and greases from purchased materials. Not included are facilities manufacturing and distributing gasoline, or facilities primarily engaged in producing coke and its byproducts (OMB 1972). No reliable data on the number of SIC 29 facilities were available during this study.

- Primary Metals (SIC 33) - Facilities engaged in smelting and refining of ferrous and nonferrous metals from ore, pig, or scrap; rolling, drawing, and alloying of ferrous and nonferrous metals; manufacture of castings and other basic products of ferrous and nonferrous metals; and manufacture of nails, spikes, and insulated wire and cable. Coke production is also included in this category (OMB 1972). There were 2,183 facilities in this industrial category in 1977 (U.S. Census of Manufacturers 1977).

- Construction - Special Trade Contractors (SIC 17) - Hazardous waste treatment, storage, and disposal (TSD) management facilities are the primary generators of hazardous waste under SIC category 17. Also included are general and specialized contractors who perform construction activities including: industrial machinery and equipment installation; plumbing, painting, plastering, and carpentering; grave excavation; gas leakage detection; and water well drilling (OMB 1972). There were 2,096 special trade contractors in the U.S. in 1983 (U.S. Census of Manufacturers 1977).

- Fabricated Metal Products (SIC 34) - Facilities that fabricate ferrous and nonferrous metal products such as metal cans, tinware, handtools, cutlery, general hardware, nonelectrical heating apparatus, fabricated structural metal products, metal forgings, metal stampings, ordnance (except vehicles and guided missiles), and a variety of metal and wire products not elsewhere classified. Not included are the primary metals industries (SIC 33) and facilities fabricating machinery, transportation equipment, scientific and controlling instruments, watches and clocks, jewelry, and silverware (OMB 1972). There were 33,478 Fabricated Metal Products facilities in 1983 (U.S. Census of Manufacturers 1977).

- Electrical and Electronic Machinery, Equipment, and Supplies (SIC 36) - Facilities that manufacture machinery, apparatus, and supplies for the generation, storage, transmission, transformation, and use of electrical energy. Included is the manufacture of household appliances. Not included are the SIC 35 industries or facilities that manufacture instruments for indicating, measuring, or recording electrical quantities (OMB 1972). In 1983, there were 14,975 facilities in this industrial category (U.S. Census of Manufacturers 1977).

- Electric, Gas, and Sanitary Services (SIC 49) - Facilities engaged in the generation, transmission, and/or distribution of electricity or gas or steam or combinations of any of these services; may also include related transportation, communication, and refrigeration. POTWs and water and irrigation systems are included (OMB 1972). No reliable data on the number of SIC 49 facilities were available during this study.

Small Quantity Generators

Small quantity generators (SQGs) are facilities generating less than 1,000 kg/month of hazardous wastes (40 CFR 260.10; 51 FR 10174, March 24, 1986). The 1984 National Small Quantity Generator Survey (Ruder et al. 1985) grouped primary target industries (those likely to generate hazardous wastes) into categories as listed in Table 2-5. This table illustrates the broad range of industries included in the SQG survey. For purposes of comparison, corresponding SIC codes are listed. Some SIC codes appear in more than one survey category. Of all the SIC groups listed in Table 2-5, eight SIC groups parallel those identified as high volume generators in the 1981 RIA Mail Survey, namely: SICs 17, 28, 33, 34, 35, 36, 37, and 42.

A profile of SQG industries and practices may be drawn by examination of data compiled by Ruder et al. (1985). For example, the 940,000 metric tons of hazardous waste generated by SQGs during 1981 was less than one-half of one percent of the

Table 2-5 SIC Classification of Small Quantity Generators by Industrial Groups Targeted by the National Small Quantity Generator Survey

Small quantity generator (SQG) industry group	Corresponding SIC classifications	
	SIC code	SIC description
Vehicle maintenance	07	Agricultural services
	16	Construction other than building construction - general contractors
	17*	Construction - special trade contractors
	42*	Motor freight transportation & warehousing
	44	Water transportation
	52	Building materials, hardware, garden supply, and mobile home dealers
	55	Automotive dealers & gasoline service stations
	75	Automotive repair, services, & garages
Chemical manufacturing	28*	Chemicals & allied products
Textile manufacturing	22	Textile mill products
Metal manufacturing	25	Furniture & fixtures
	33*	Primary metal industries
	34*	Fabricated metal products
	35*	Machinery, except electrical
	36*	Electrical & electronic machinery, equipment, & supplies
	37*	Transportation equipment
	39	Miscellaneous manufacturing industries
Other manufacturing	7	Agricultural services
	30	Rubber & miscellaneous plastic products
	31	Leather & leather products
	32	Stone, clay, glass, & concrete products
Furniture/Wood manufacturing & refinishing	24	Lumber & wood products, except furniture
	25	Furniture & fixtures
	76	Miscellaneous repair services

Table 2-5 (continued)

	Corresponding SIC classifications	
Small quantity generator (SQG) industry group	SIC code	SIC description
Cleaning agents & cosmetic manufacturers	28*	Chemicals & allied products
Formulators	28*	Chemicals & allied products
Wood preserving	24	Lumber & wood products, except furniture
Pesticide end-users	79	Amusement: recreational services, except motion pictures
	84	Museums, art galleries, botanical & zoological gardens
Pesticide application services	07	Agricultural services
	49	Electric, gas, & sanitary services
	73	Business services
Construction	17*	Construction-special trade contractors
	24	Lumber & wood products, except furniture
	40	Railroad transportation
Shipment/repair	46	Pipelines, except natural gas
	48	Communication
	59	Miscellaneous retail
	72	Personal services
	76	Miscellaneous repair services
	79	Amusement & recreation services, except motion pictures
Motor freight terminals	42*	Motor freight transportation & warehousing
Laundries	72	Personal services

Table 2-5 (continued)

Small quantity generator (SQG) industry group	Corresponding SIC classifications SIC code	SIC description
Photography	73	Business services
	84	Museums, art galleries, botanical & zoological gardens
Printing/ceramics	26	Paper & allied products
	27	Printing, publishing, & allied industries
	32	Stone, clay, glass, & concrete products
	73	Business services
Paper industry	26	Paper & allied products
Analytic & clinical laboratories	73	Business services
	80	Health services
	82	Educational services
Educational & vocational shops	89	Miscellaneous services
	82	Educational services
	83	Social services
Wholesale & retail sales	51	Wholesale trade-nondurable goods
	52	Building materials, hardware, garden supply, & mobile home dealers
Other services	72	Personal services
	73	Business services

Source: Ruder et al. 1985.

*Comparable SIC Included in Ten Highest Volume Generator Industries, 1981 RIA Generator Survey.

total volume of hazardous waste reported generated during that year (Westat 1984 and Ruder et al. 1985). In 1984, however, this small fraction of the total waste generated accounted for waste generation practices at 98 percent of the generator facilities (Ruder et al. 1985). The SQG profile is dominated by nonmanufacturing industries and closely associated with major population centers. The Vehicle Maintenance survey category alone accounted for 50 percent of all SQG facilities and 71 percent of the total quantity of hazardous waste generated by SQGs nationwide. Other nonmanufacturing industries made up an additional 23 percent of the SQGs and 15 percent of the total waste generated. Metal manufacturing SQGs generated 9 percent of the total waste generated by SQGs.

The distribution of SQGs among industry groups is consistent with the types of waste streams generated by SQGs during 1984. For example, 62 percent (370,000 million tons) of all waste generated by SQGs in that year consisted of lead acid batteries. The lead acid batteries wastes were generated by the SQG vehicle maintenance industries. Another 18 percent (108,000 metric tons) were solvent wastes generated by SQG metal manufacturing, vehicle maintenance, equipment repair, printing, and construction industries (Ruder et al. 1985). Five percent (30,000 metric tons) were acid or alkaline (corrosive) wastes (Ruder et al. 1985). No specific waste classification was given for the remaining 15 percent (90,000 metric tons) of waste generated by SQGs.

2.2.1 Characteristic Waste Stream Generation and Recycling

The profile of hazardous waste generation by U.S. industries also can be characterized by the types of waste streams generated in high volumes. Table 2-6 lists the volume of RCRA characteristic waste generation by ignitability characteristic (D001), corrositivity characteristic (D002), EP-toxicity characteristic (D000, D004-D007), and reactive characteristic (D003), reported to be generated by the ten highest-volume generator industries in 1981.

The ignitable wastes consist mainly of solvent wastes and also some metal and cyanide/reactive wastes; the corrosive wastes are acids and alkalies; EP-toxic wastes include heavy metal wastes and pesticides; and reactive wastes include

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Table 2-6 Profile of RCRA Characteristic Waste Generation by the Ten Highest Volume Waste Generating Industries in 1981

SIC	Industry description	Volume of waste generated (M gal)							
		Ignitability characteristic (D001)	(Percent)[a]	Corrosivity characteristic (D002)	(Percent)[a]	EP-toxicity characteristic (D000, D004-D007)	(Percent)[a]	Reactive characteristic (D003)	(Percent)[a]
28	Chemical and Allied Products	140	(0.5)	8,200	(29)	1,200	(4.2)	15,000	(54)
35	Machinery, Except Electrical	67	(1.6)[a]	2,300	(54)[a]	71	(17)[a]	< 0.1	
37	Transportation Equipment	40	(2.1)[a]	950	(49)[a]	530	(28)[a]	< 0.1	
42	Motor Freight Transportation and Warehousing	< 0.1		< 0.1		0.7		NR[c]	
29	Petroleum and Coal Products	8.3	(10)[a]	51	(61)[a]	1.8	(2.2)[a]	< 0.1	
33	Primary Metals	2.9	(0.4)[a]	220	(26)[a]	560	(68)[a]	31	(< 0.1)
17	Construction, Special Trade Contractors[b]	< 0.1		870	(100)	430	(49)	< 0.1	
34	Fabricated Metal Products[b]	5.4	(0.6)	310	(38)	320	(39)	240	(29)
36	Electrical Equipment Manufacture	15	(2.4)[a]	170	(28)[a]	40	(6.6)[a]	40	(2.6)[a]
49	Electric, Gas, and Sanitary Services (includes POTWs)	< 0.1		32	(6.8)	38	(8)	38	(8)

Source: RIA Mail Survey for generators.

[a] Percent of total waste generated by this industry.

[b] Because of inconsistencies in the data base, the sum of the characteristic waste volumes reported under each category is greater than 100 percent of the total waste volume reported for this SIC.

[c] None reported.

explosives and propellants. Of the characteristic waste streams listed, corrosive characteristic wastes are generated in the highest volumes. This is consistent with the large-scale use of acids and alkalies in the chemical, petroleum, and metal finishing industries. Many of the corrosive waste streams also contain heavy metals as indicated by the high volumes of EP-toxic wastes reported by most industries. Ignitable (solvent) waste generation was reported in the lowest volume for all RCRA characteristic wastes. Reactive characteristic wastes are attributable mainly to the Chemicals and Allied Products industry (SIC 28).

2.2.2 Generation and Management Profile by Waste Category

The following discussion presents an overview of management practices for each of the following categories of wastes: solvents, halogenated (nonsolvent) organics, metals, corrosives, and cyanide/reactive wastes.

Solvent Wastes

Solvent waste generators include primarily the industrial users of prepared solvents. For example, spent, contaminated solvents are generated:

- By paint and coatings plants that use solvents to clean equipment tanks (Campbell & Glenn 1982);
- By manufacturers of pharmaceuticals, cosmetics, toiletries, food products, and lubricants;
- In metal working and machine maintenance shops during degreasing of equipment;
- Through cleaning of surfaces in the plastics fabrication, electrical, electronics, and printing industries;
- By dry cleaning operations;
- In paint stripping operations;
- During drying and equipment cleaning processes in the adhesives and sealants industry; and
- During extraction of lube oils and waxes in the petroleum refining industry.

A study of (virgin) solvent end-uses indicated that of the total volume of solvents used in 1981, the following industrial applications consumed the amounts shown below (Pace 1983):

Industrial application	Percent of total solvents used in 1981
Paints/coatings/inks	44
Process solvent	23
Metal cleaning (degreasing)	17
Dry cleaning	5
Adhesives	4
Other	7
	100

The Chemicals and Allied Products industry (SIC 28) uses solvents for formulation of paints, coatings, and inks and in various processes. These two categories of industrial applications made up 67 percent of the total solvents used in 1981 (Pace 1983).

Management practices of the Chemicals and Allied Products industries (SIC 28) for nonhalogenated and halogenated solvent waste streams are illustrated in Figures 2-2 and 2-3, respectively. More than one management practice may be used for a particular waste (e.g., onsite wastewater treatment followed by wastewater discharge). Therefore, the total of all practices represented in Figures 2-2 and 2-3 exceeds 100 percent for both halogenated and nonhalogenated solvents, respectively. The figures suggest that wastewater discharge is a common management strategy for waste streams containing solvents, and less than 10 percent of SIC 28 solvent wastes generated are recovered or reused.

Halogenated Organic (Nonsolvent) Wastes

Halogenated organic wastes that are not characterized as solvents include wastes from a broad class of synthetic organic chemicals characterized by the presence of the halogens (chlorine, bromine, or fluorine) in hydrocarbon compounds. Approximately 24.2 million gallons of halogenated organic wastes (excluding solvents) were generated during 1981 (GCA Corporation 1984).

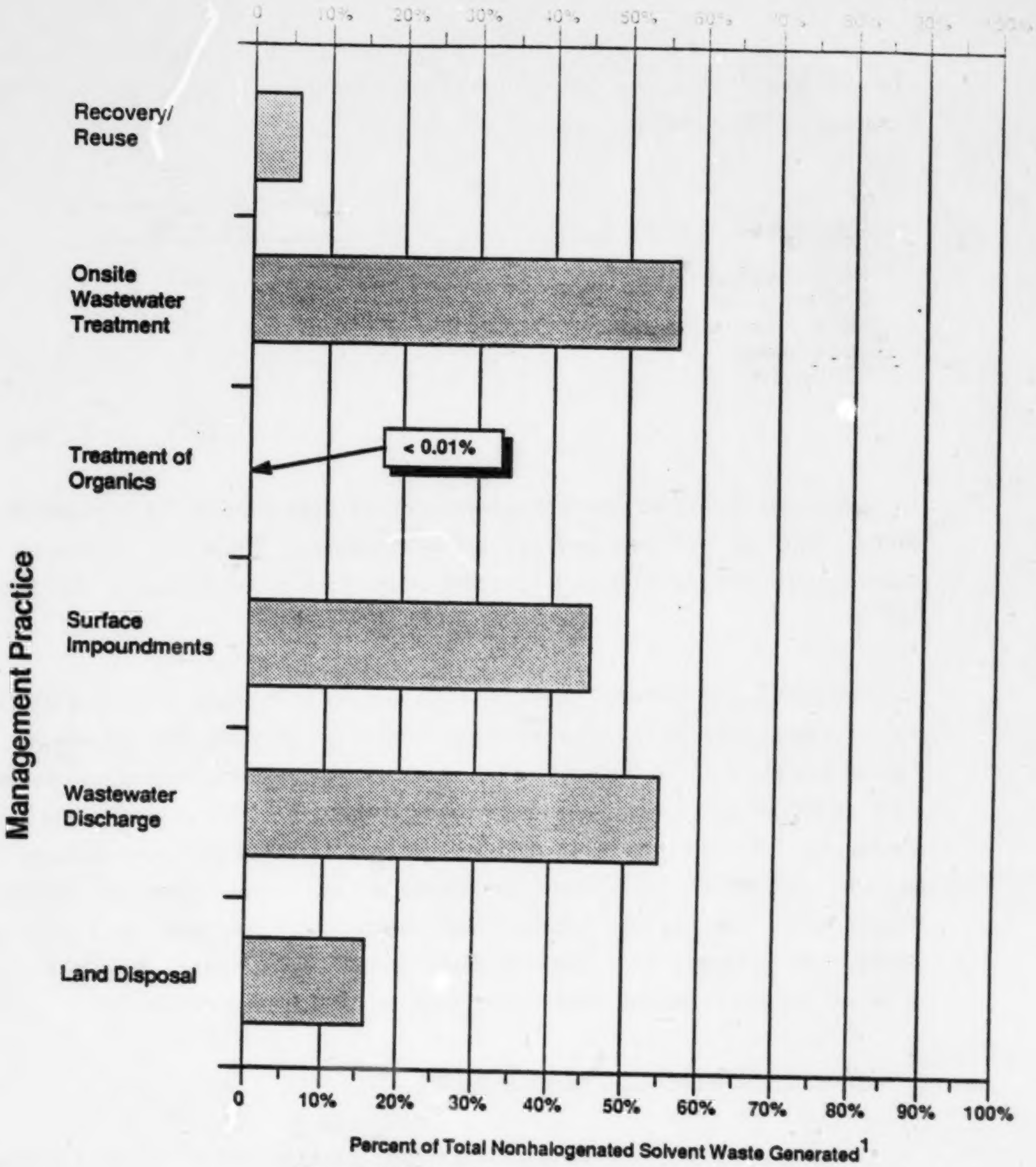


Figure 2-2 Management Practices of the Chemical and Allied Products Industries (SIC 28) for Waste Streams Containing Nonhalogenated Solvents[2]

[1] Total of all practices exceeds 100% because of overlapping management practices

[2] Total nonhalogenated solvent waste quantity managed = 31,533,503 tons/year

Source: Industrial Studies Data Base

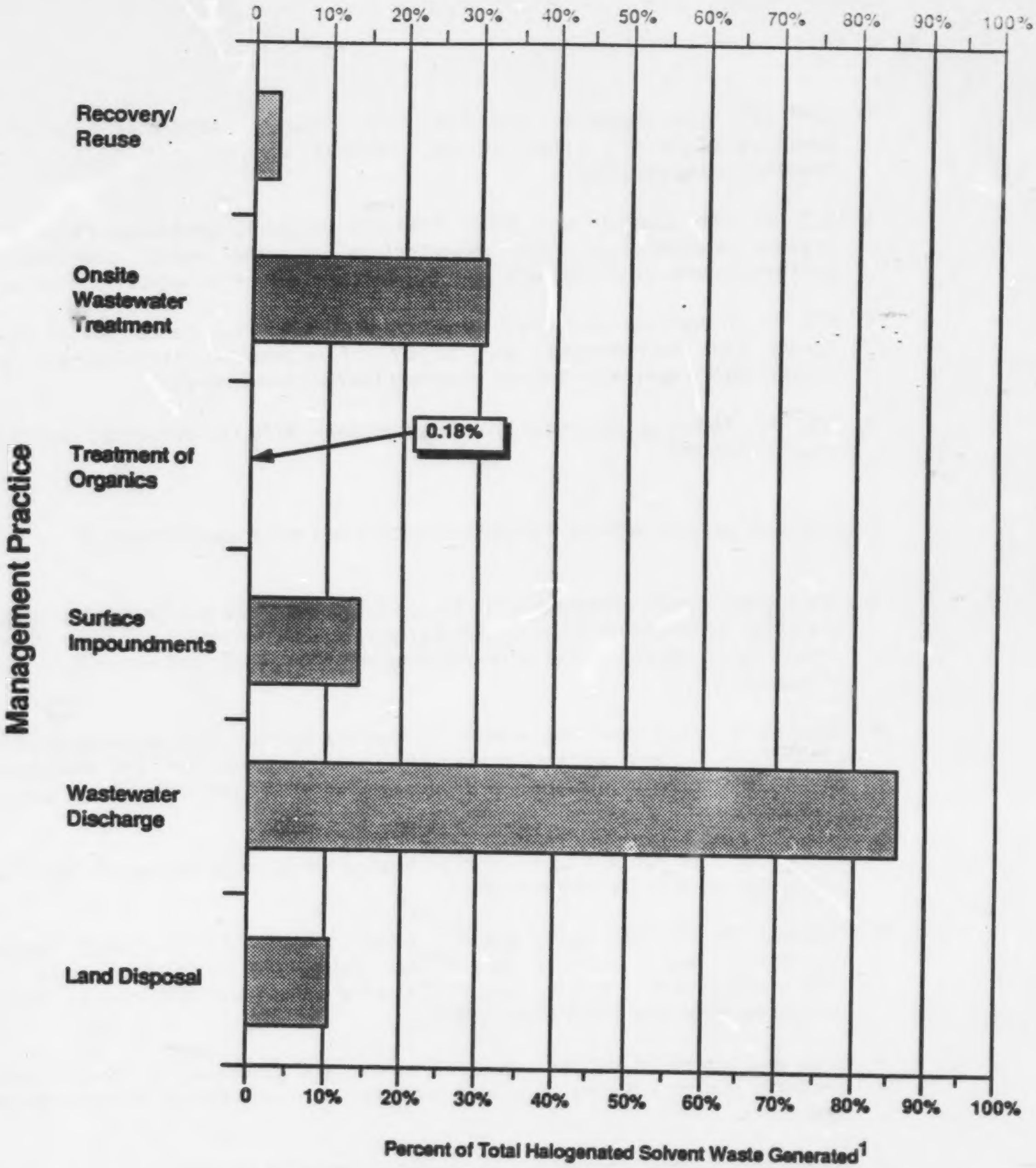


Figure 2-3 Management Practices of the Chemical and Allied Products Industries (SIC 28) for Waste Streams Containing Halogenated Solvents[2]

[1] Total of all practices exceeds 100% because of overlapping management practices

[2] Total halogenated solvent waste quantity managed = 7,801,684 tons/year

Source: Industrial Studies Data Base

Generators of such halogenated organic wastes identified by the RIA Mail Survey include the following SICs:

- SIC 287, the Pesticide and Fertilizer Industry, generates chlorinated pesticide dusts and rinse waters. (Wastes are recycled back to the manufacturing process).

- SIC 24, the Lumber and Wood Products industry, generates chlorinated organic wastes from the manufacture of the wood preservative, pentachlorophenol (PCP), and from application of PCP to lumber products.

- SIC 76, Miscellaneous Repair Services, generates PCB-contaminated fluids during the maintenance and repair of electrical transformers and contaminated specialty organic cleaning fluids (nonsolvent).

- SIC 97, National Security and International Affairs, generates specialty organic wastes.

Halogenated organic wastes include both liquid and solid waste streams:

- Wastewaters contaminated with halogenated organics are generated during chemical manufacture from aqueous process steps, solvent extraction, water scrubbing of vapors, water washing of organic products, and water quenching of reactions.

- Sources of liquid pesticide wastes containing halogenated organics include production process waters, rinse waters from container and equipment rinsing and cleaning, off-spec products, outdated pesticides, and banned pesticides.

- Spent solutions containing wood preservatives may be generated at facilities where the wood is treated and dried.

- Drained transformer fluids are the major source of liquid PCB wastes containing greater than 50 ppm PCBs. Approximately 60 percent of the PCB transformers in service (as of 1979) were owned and operated by utility companies (Radimsky and Marx 1983).

- Solid and semisolid still bottom-type wastes are generated by the pesticide chemical industry during processes such as the manufacture of chlorinated pesticides.

- Solids and sludges containing halogenated organics of distillation residues, include residues from reclamation of solvent wastes (still bottoms) and sludges from equipment cleaning operations (degreasing sludges). Still bottoms may contain metal catalyst particles, other metal fines, high-boiling halogenated organic byproducts, and impurities (e.g., greases, tars, and polymers). Degreasing sludges are generated from the clean-out of degreasing equipment. The cleaning results in sludges that comprise metal fines, grit, oil, and grease-containing halogenated organics.

The management of halogenated nonsolvent organic waste by the Chemicals and Allied Products industries (SIC 28) is illustrated in Figure 2-4. Over 90 percent of the volume of wastes containing halogenated organics is managed by wastewater discharge. The fraction of such wastes that are recovered is less than 1 percent, reflecting the technical difficulty of separating constituents from organic sludges, and the lack of uses for the untreated sludges.

Metal Wastes

The estimated total volume of all metal-bearing wastes generated in the United States for 1981 was 7.9 billion gallons (30 million metric tons). Of that total volume generated, approximately 5.6 billion gallons (21 million metric tons) were treated or stored (Versar 1984), 1.7 billion gallons (6.4 million metric tons) were land disposed (Versar 1984), and less than 0.7 million gallons (2.6 metric tons) were recycled (RIA Mail Survey). Of the waste recycled, the RIA Mail Survey indicates that 7 percent was handled offsite and 93 percent was managed onsite.

Examples of processes resulting in generation of inorganic or organometallic metal-bearing waste streams include the following:

- Electroplating, photofinishing, and printing industries commonly produce process and rinse waters contaminated with silver, nickel, zinc, tin, copper, chromium, lead, or cadmium.
- Equipment cleaning in the steel and metallurgical industries generates acidic or alkaline solutions containing toxic metals and dissolved oils, greases, and oxides.
- Degreasing operations in metal parts fabrication industries generate organic liquids or solvents laden with metal particulates. Also, flue dusts high in zinc result from galvanizing operations and dusts from electric arc stainless steel production contain nickel and chromium.
- Metal hydroxide or carbonate sludges often result from treatment processes that remove metals from aqueous wastes generated by the electroplating and metal finishing industries (Stoddard 1981).

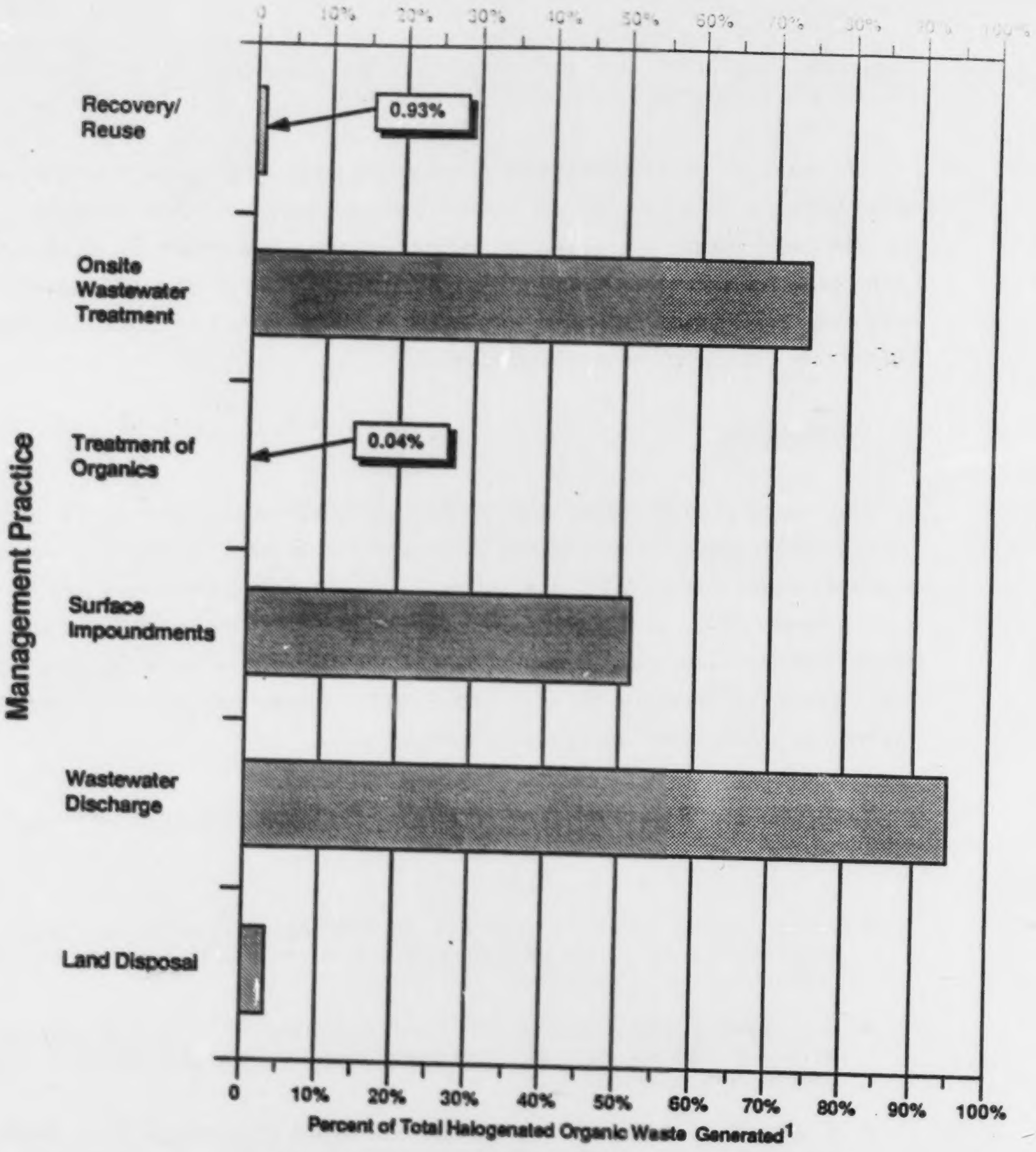


Figure 2-4 Management Practices of the Chemical and Allied Products Industries (SIC 28) for Waste Streams Containing Halogenated (Nonsolvent) Organic Wastes[2]

[1] Total of all practices exceeds 100% because of overlapping management practices

[2] Total halogenated organic waste quantity managed = 26,478,501 tons/year

Source: Industrial Studies Data Base

- The manufacture of leaded gasoline and paint generates metal-bearing sludges.

Metal finishing processes in the Primary Metal (SIC 33), Fabricated Metal Products (SIC 34), Machinery, Except Electrical (SIC 35), Electrical and Electronic (SIC 36), and Transportation Equipment (SIC 37) industries account for the largest volumes of metal-bearing wastes reported in the RIA Mail Survey for the study year 1981.

Figure 2-5 illustrates the management of the small volume of metal-bearing waste streams generated by the Chemicals and Allied Products industries (SIC 28). The percent of such waste streams that is land disposed is greater than that reported for solvent and nonsolvent organic wastes (Figures 2-2 through 2-4). These wastes are apparently stored in surface impoundments (presumably for treatment and separation) prior to disposal. The low recovery reuse rate is not typical of U.S. industries as a whole (see Section 4.2), but indicative of the lack of reuses for metal constituents from these wastes in the chemical industry.

Corrosive Wastes

Corrosive wastes are generated by industries that use acidic or alkaline solutions in production or finishing processes. Some examples of processes in which corrosive wastes are generated include the following:

- The metal finishing industries (SIC 33 to 37) produce corrosive wastes from processes including electroplating, conversion coating, etching, cleaning, barrel finishing, (tumbling), and heat treating. Spent alkaline cleaning solutions (e.g., sodium hydroxide, sodium carbonate) and pickling (acid) solutions (e.g., hydrochloric, sulfuric, or chromic acid) are among the most frequently generated wastes.
- The Electrical and Electronics industry (SIC 36) generates spent metal-bearing acid solutions from the cleaning of scale from metals in the production of semiconductors and from etching of metal circuit boards.
- The Textile Mill Products industry (SIC 22) generates spent sodium hydroxide from mercerizing.
- A high volume of "spent acid" is generated by the Chemicals and Allied Products industry (SIC 28) in production processes where corrosive solutions are used as dehydrating agents or catalysts.

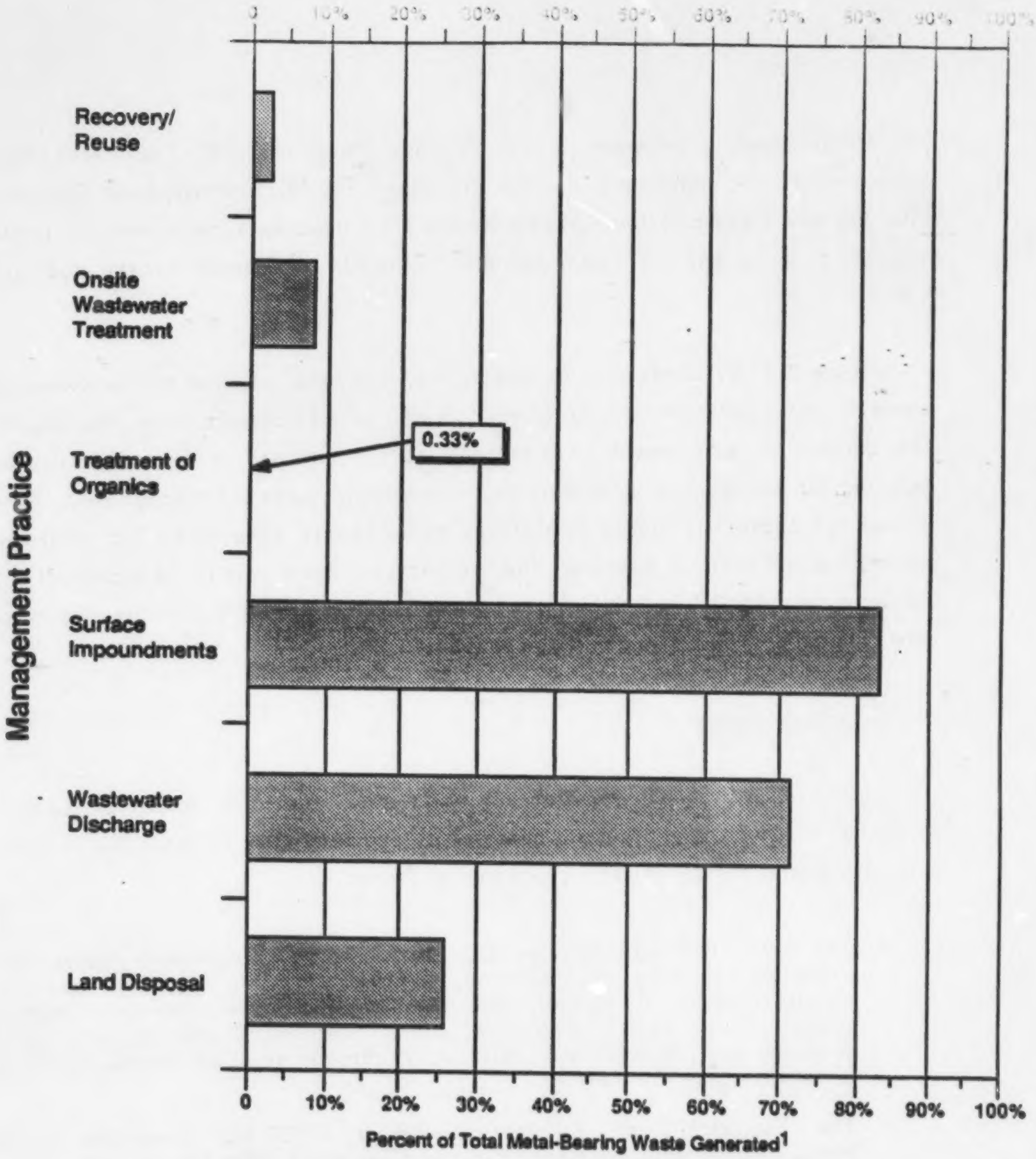


Figure 2-5 Management Practices of the Chemical and Allied Products Industries (SIC 28) for Metal-Bearing Waste Streams[2]

[1] Total of all practices exceeds 100% because of overlapping management practices

[2] Total metal waste quantity managed = 359,321 tons/year

Source: Industrial Studies Data Base

Management of corrosive wastes in surface impoundments, by onsite wastewater treatment, wastewater discharge, or land disposal are reported by the SIC 28 industries. The percentages of corrosive constituent waste streams that are managed by each of these practices are illustrated in Figure 2-6.

Cyanide and Reactive Wastes

The category of cyanide and reactive wastes includes wastes with cyanide constituents (including complexes and organic and inorganic cyanides), sulfides, explosives, water reactives, and strong oxidizers and reductants. Cyanides and metal wastes are often generated by the same process and are thus contained in the same waste streams. For example, copper cyanide waste is generated from copper plating operations.

Unlike solvents or corrosives, which are generated by a broad spectrum of industries, cyanide wastes, like metal wastes, are generated predominantly within the Metal Finishing and Processing (SIC 33 to 37) industries. Cyanide wastes are also generated by the following industries: Industrial Inorganic Chemicals (SIC 2819), Industrial Organic Chemicals (SIC 2869), Plastic Materials (SIC 2821), and National Security (SIC 9711) (Versar 1984).

The Chemicals and Allied Products industry (SIC 28) produces water reactive wastes containing sodium, sulfides, phosphorus, and potassium. The mining, quarrying, and excavating industries (SICs 10, 14, and 17) and the National Security industry (SIC 9711) generate reactive wastes such as explosives and propellants that are off-specification or beyond their shelf life.

Generating processes for cyanide/reactive wastes include the following:

- Cyanide baths used in the Metal Finishing and Processing industries (SIC 33 to 37) to keep soluble metals such as copper, nickel, silver, cadmium, or zinc in solution so that they can be used in either electroplating or stripping solutions;
- Spent process solutions, contaminated rinse waters, and accidental spills from the Metal Finishing and Processing industry;

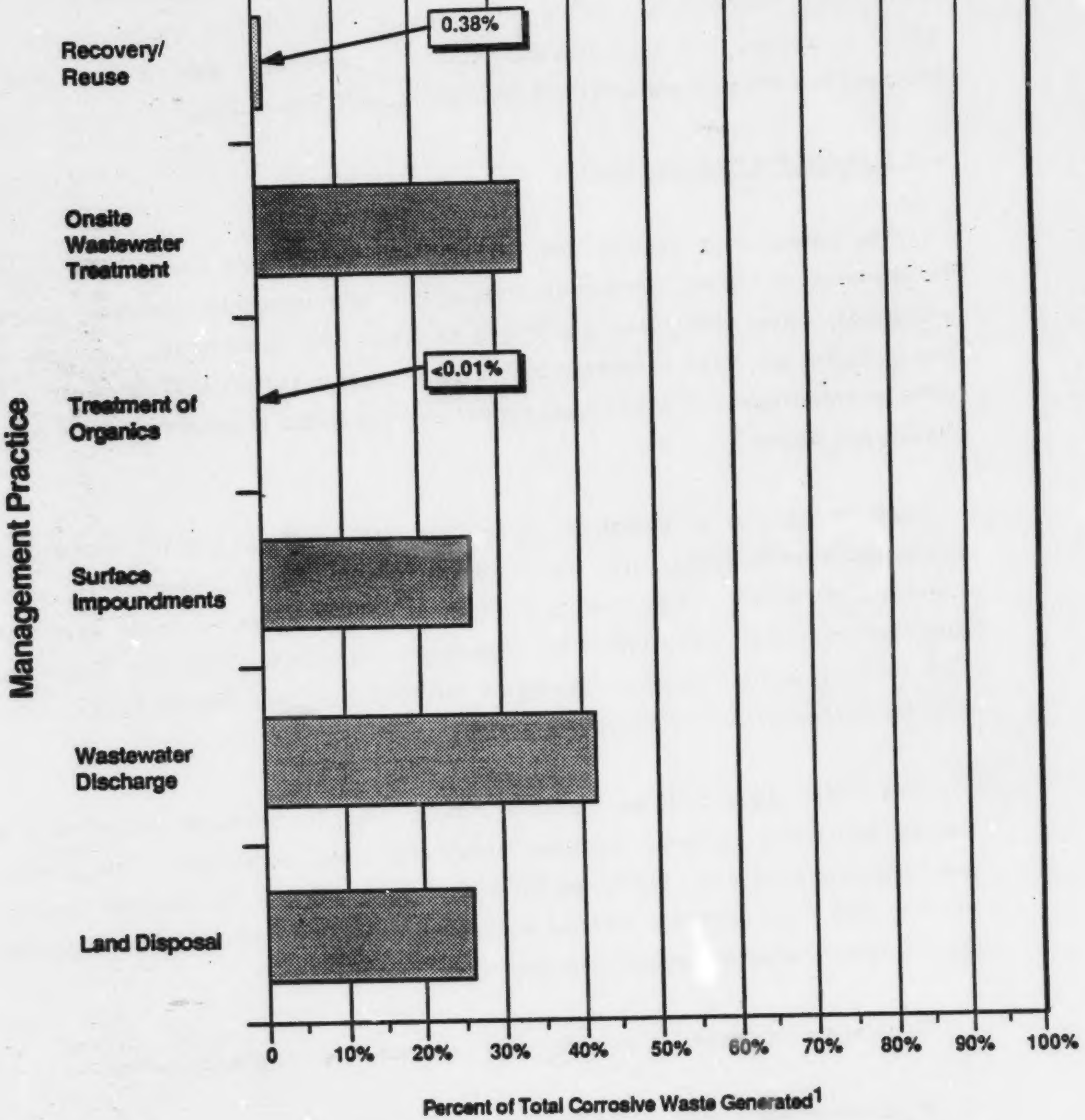


Figure 2-6 Management Practices of the Chemical and Allied Products Industries (SIC 28) for Waste Streams Containing Corrosive Wastes[2]

[1] Total of all practices exceeds 100% because of overlapping management practices

[2] Total corrosive waste quantity managed = 9,378,783 tons/year

Source: Industrial Studies Data Base

- Contaminated rinse waters generally having cyanide concentrations below 100 ppm (usually 10 to 20 ppm), and spent process solutions having concentrations above 1,000 ppm (Radimsky, Piacentini, and Diebler 1983); and
- Other reactive wastes generated by industries involved in explosives and propellant manufacture.

Figure 2-7 illustrates the management practices employed by the Chemicals and Allied Products industries (SIC 28) for cyanide/reactive wastes. Management is predominantly by wastewater discharge, presumably following separation or treatment in surface impoundments. The very small fraction of such waste streams that are recovered or reused suggests limited technology for recovery and few identified uses for recoverable constituents.

2.3 Process - Specific Waste Generation Profile

In order to examine the major sources of hazardous waste generation in more detail, a study was conducted to assess the amount of waste generated from specific processes within the Chemicals and Allied Products industry (SIC 28). This industry was chosen since it is responsible for generating the largest portion of hazardous waste in the U.S. The study was based on waste generation data contained in the Industry Studies Data Base (ISDB). The principal goal was to rank the various chemical processes reported in the ISDB based on four different groupings. These included:

- Nationwide total waste generation rate;
- Nationwide hazardous (RCRA) waste generation rate;
- Specific total waste generation rate (lb total waste per lb product); and
- Specific hazardous waste generation rate (lb hazardous waste per lb product).

The methodology used to differentiate the different waste sources was based on the grouping of waste generation data from all processes used to manufacture a particular product. The ISDB contains only data from surveys of a number of representative chemical manufacturing facilities. Scale-up of ISDB data to nationwide estimates for 1984 was made based on total number of facilities and total production quantities in 1984 for each product/process category. Since a

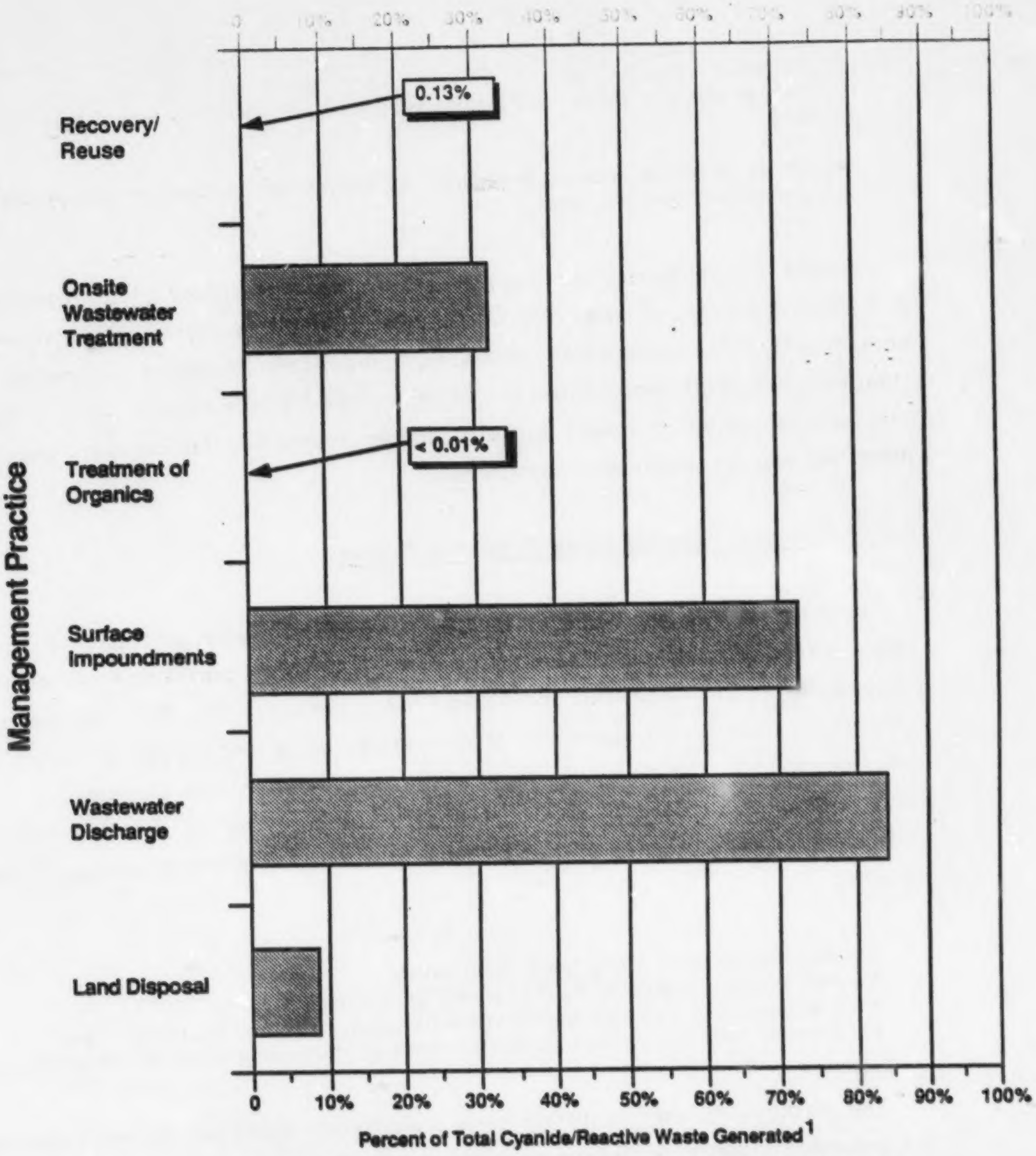


Figure 2-7 Management Practices of the Chemical and Allied Products Industries (SIC 28) for Waste Streams Containing Cyanide/Reactive Wastes[2]

[1] Total of all practices exceeds 100% because of overlapping management practices

[2] Total cyanide/reactive quantity managed = 14,618,951 tons/year

Source: Industrial Studies Data Base

single process can often be used to generate more than one product, this methodology may result in double counting, as well as overestimating the waste generation rates from the manufacture of a single product. Because of these limitations, the results of this study should be used with caution - only a qualitative assessment of the relative magnitude of waste generation from the manufacture of different products can be made.

Tables 2-7 to 2-10 contain the listings of the top 20 products that are responsible for producing the major portion of the waste generated from the SIC 28 industry, according to the four criteria mentioned above. Because of RCRA Confidential Business Information (CBI) constraints, only generic descriptors are given for products manufactured at less than three facilities. In addition, the products were ranked in the order of decreasing waste generation. These rankings, however, take into account waste generation not only associated with the manufacturing of the cited products, but also waste generation from any coproducts using the same chemical processes. Again, therefore, the rankings should be viewed with caution.

The following observations were made on the process-specific pattern of waste generation from the Chemicals and Allied Products industry (SIC 28):

- Products characterized by high value of specific total waste generation (lb waste/lb product) are generally not the same as those which produce large amounts of total waste and/or total hazardous waste.
- Products characterized by high value of specific hazardous waste (lb hazardous waste/lb product) are generally not the same as those generating large amounts of total waste. Similarly, only 30 percent of the major products with high value of specific hazardous waste are the same as those responsible for generating large amounts of total hazardous waste.
- All major products with high specific waste generation rates are manufactured at fewer than three facilities. In addition, the majority of these products are manufactured in only small quantities (less than 10,000 metric tons/yr).
- Products that generate large amounts of total waste generally do not generate large amounts of hazardous waste. Similarly, the percentage of the total waste that is hazardous is often very high for those products generating large amounts of hazardous waste.

Table 2-7 List of Major Products Based on Nationwide Total Waste Generation Rates

---

1. Toluene
2. Propylene
3. Secondary Amine, Amino*
4. Ethylene
5. Sec. Dialkyl Amine, Amino*
6. Polyvinyl Chloride*
7. Phenol
8. Noncyclic Aliph. Alcohol, Amino*
9. Biphenyl, Amino, Chloro*
10. Benzene
11. Acetone
12. Epoxide, Chloro*
13. Naphthalene
14. Epoxide*
15. Methylene Diphenyldiisocyanate (MDI)
16. Butanol
17. Cumene
18. Organic*
19. Polystyrene/ABS*
20. Copolymer, Chloro*

Source: Industrial Studies Data Base.

*Non CBI Descriptor.

Table 2-8 List of Major Products Based on Nationwide Hazardous Waste Generation Rates

1. Propylene
2. Biphenyl, Amino, Chloro*
3. Phenol
4. Ethylene
5. Polystyrene/ABS*
6. Benzene, Amino, Chloro*
7. Alkane, Iso/Isothiocyan*
8. Alkane, Carboxylic*
9. Aklyl Metal Coord., Alkyl (Sat)-PB*
10. Acetone
11. Cyclic Alkane, Alkyl (Unsat)*
12. Benzene, Amino*
13. Alkane, Cyano/Thiocyano*
14. Maleic Anhydride
15. Organic*
16. Methyl Methacrylate
17. Cyclic Alkane, Keto*
18. A-Methyl Styrene
19. Xylene
20. Alkane, Nitro*

Source: Industrial Studies Data Base.

*Non CBI Descriptor.

Table 2-9 List of Major Products Based on Specific Total Waste Generation Rates (lb Total Waste/lb Product)

---

1. Cyclic Ester, Substituent*
2. Biphenyl, Amino, Chloro*
3. Sec. Amine, Amino*
4. Phosphorodithioate, Sub.-SR*
5. Benzene, Amino*
6. Thiourea, Amino*
7. Benzene, Amino, Chloro*
8. Copolymer*
9. Benzene, Amino, Alkyl (Sat)-Phenyl*
10. Alkyl (Sat)*
11. Aklyl Phenyl Amine, Amino*
12. Sec. Dialkyl Amine, Amino*
13. Polyester/Alkyl Resin*
14. Noncyclic Aliph. Alcohol, Amino*
15. Benzothiazole, Thio*
16. Sulfate-CR*
17. N,N Alkyl Phenyl Amide, Chloro*
18. Pyridine, Amino*
19. Dialkyl Ether, Substituent*
20. Diphenyl Thioether, Hydroxy, Alkyl (Sat)*

Source: Industrial Studies Data Base.

*Non CBI Descriptor.

Table 2-10 List of Major Products Based on Specific Hazardous Waste Generation Rates (lb Total Waste/lb Product)

---

1. Biphenyl, Amino, Chloro*
2. Benzene, Amino, Chloro*
3. Cyclic Ester, Substituent*
4. Benzene, Amino*
5. Benzene, Amino, Chloro, Nitro*
6. Benzene, Chloro, Nitro, Sulfonyl*
7. Cyclic Alkadiene, Hydroxy*
8. Dye/Pigment*
9. Phthalocyanide Dye/Pigment*
10. Sulfate-CR*
11. Alkyl Hydrazine*
12. Alkane, Iso/Isothiocyan*
13. N, N Alkyl Phenyl Amide, Chloro*
14. Diphenyl Thioether, Hydroxy, Alkyl (Sat)*
15. Alkyl Metal Coord., Alkyl (Sat)-PB*
16. Alkyl Phenyl Amine, Chloro, Chloro*
17. Cyclic Alkane, Alkyl (Unsat)*
18. Furan, Alkyl (Unsat), Benzyl, Cycloalkyl*
19. Diether, Chloro*
20. Benzene, Amino, Chloro, Alkoxy*

Source: Industrial Studies Data Base.

*Non CBI Descriptor.

The first three observations together seem to indicate that the majority of the waste is generated from the manufacture of products in great demand. The processes used to manufacture these products, however, are often continuous and well established and thus may not leave much immediate potential for waste reduction. Other chemical processes, such as those used to manufacture propylene and benzene/toluene/xylene (BTX), also appear to be responsible for the generation of large amounts of hazardous wastes.

2.4 Summary

Hazardous waste generation from industrial processes is a function of process and equipment design. The more efficient the use of raw materials in a process, the higher the product yield from a process and the lower the waste generation rate. Hazardous waste generation from processing solutions such as degreasing solvents and plating baths is a function of "good housekeeping" such as materials and waste segregation, and material conservation.

Decisions to employ waste minimizing (yield maximizing) process and equipment designs depend on complex economic, motivational, and regulatory factors. Examples include:

- Costs of waste minimization include the analysis of the process design and operation options, as well as the capital investment in the equipment itself.
- Evaluations of costs vs. competitiveness and quality of the product are influenced by the attitudes of individuals and corporate management.
- Compliance with existing regulations is an important factor in process design. Some tradeoffs among waste streams are inevitable, especially from emissions that are concentrated as a solid waste to meet air emission standards.
- Product conservation by consumers and efforts to produce more durable goods result in an overall reduction of waste generated in the chain of processes leading to product manufacture.

The profile of hazardous waste generation by U.S. industries is dominated by the Chemicals and Allied Products industry (SIC 28), which generated 68 percent of the total volume of hazardous waste reported in 1981 (RIA Generator Mail Survey).

Metal finishing industries such as Machinery, Except Electrical (SIC 35) and Transportation Equipment (SIC 37) account for another 15 percent of hazardous waste generated in 1981. Less than one-half of one percent of the total hazardous waste generated is attributed to small quantity generators.

A study of process-specific wastes of the Chemicals and Allied Products industry (SIC 28), based on information in the Industrial Studies Data Base (ISDB), indicates that there is no correlation between chemical products with high specific total waste generation or high specific hazardous waste generation and chemical products with large amounts of either total waste or total hazardous waste generation. For some processes in which large amounts of hazardous waste are generated, however, the hazardous waste accounts for a large percentage of the total waste generated.

Waste streams generated in highest volume by U.S. industries (including SQGs) are corrosive wastes, spent acids, and alkalines used in the chemical, metal finishing, and petroleum refining industries. Many of these waste streams also contain high concentrations of heavy metals, making them EP-toxic wastes. Solvent (including ignitable) wastes are generated in large volumes both by the manufacturing industries and by a wide range of equipment maintenance industries that generate spent cleaning and degreasing solutions. Cyanide/reactive waste generation is confined primarily to chemical industry manufacture of specialty chemicals and spent cyanide plating solutions and sludges generated by metal finishing industries. Management practices of the Chemicals and Allied Products industry (SIC 28), reported in EPA's Industrial Studies Data Base, suggest that wastewater discharge of treated waste streams and disposal of some wastes are common industry practices, with recovery and reuse limited to halogenated and nonhalogenated solvents.

3. SOURCE REDUCTION PROFILE

Source reduction was previously defined in Section 1 as "any activity that reduces or eliminates the generation of waste within a process." This is a broad definition, and it requires further clarification. Conceptually, reduction in waste generation from an existing manufacturing process can be accomplished by (1) in-plant changes and (2) a decrease in product output.

The activities most readily identifiable with source reduction are in-plant changes. Essentially, these include alterations of the variables that are under the direct control or influence of the producer or waste generator. Implementation of in-plant modifications results in "source control" and consists of input material alterations, technology alterations, and procedural/institutional alterations.

Source control techniques are characterized and discussed in Section 3.1. The techniques are based on the 22 studies of individual processes and practices presented in Appendix B and on other information. Section 3.2 provides a summary of the individual qualitative estimates of current and future extents of waste minimization for each of the 22 processes and practices. In addition, the individual estimates have been synthesized into general approximate estimates of waste reduction for the entire U.S. industry.

A decrease in product output can also lead to source reduction. Product output is governed by the demand for that product, a factor that is external to the production unit. Product demand, in turn, is governed by a host of other factors, most of which are not under the control or even the influence of the producer or waste generator. This study has addressed reductions in product output only to the extent of partial identification of possible product substitution alternatives. Product substitution, by itself, was considered part of source reduction because it contributes (albeit indirectly) to reduction or elimination of waste produced "within a process" by decreasing demand for the product. Product substitution is discussed in greater detail in Section 3.3. An overall summary of findings and observations is provided in Section 3.4.

Source reduction, therefore, is composed of both in-plant changes (or source control) and product substitution. The interrelationship of waste minimization components is graphically depicted in Figure 3-1.

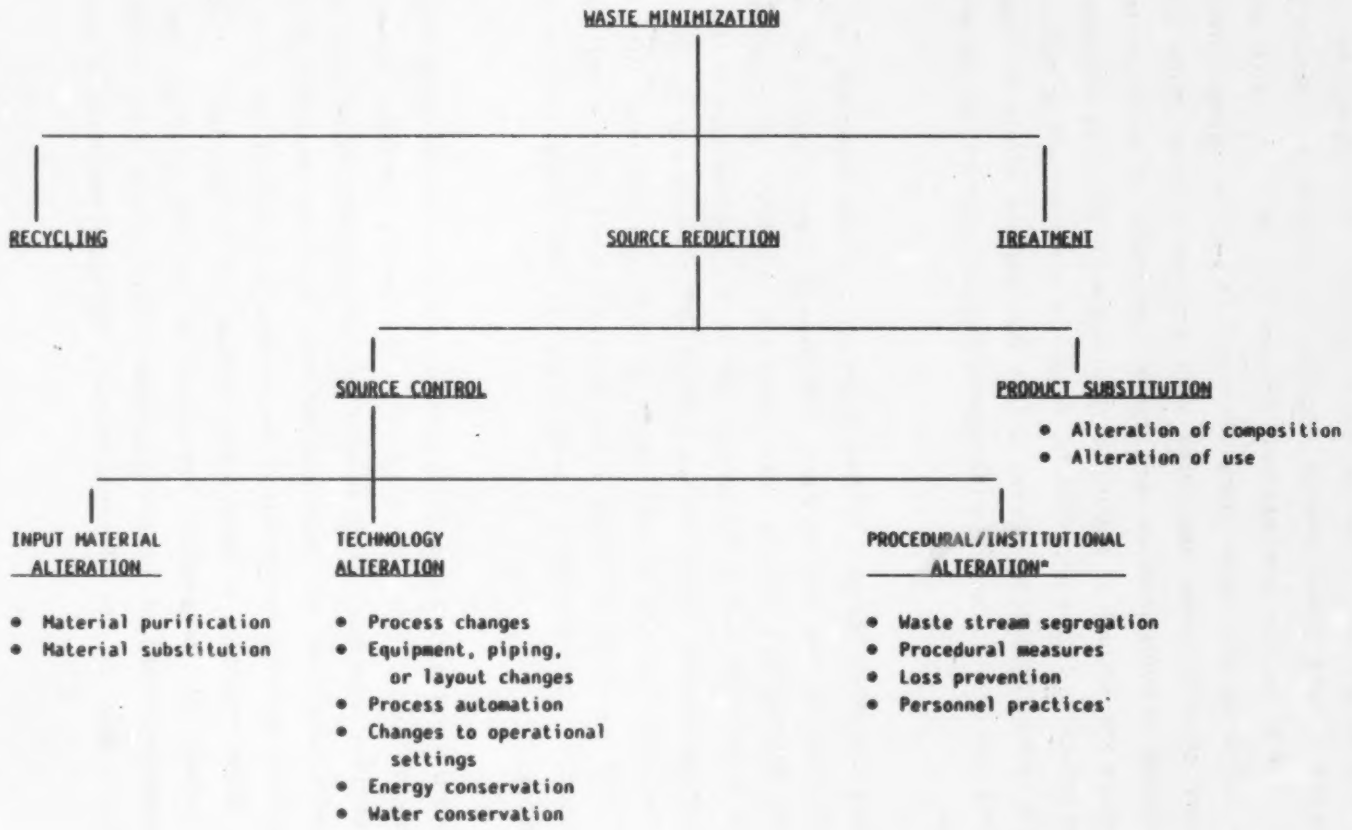
3.1 Source Control Methodology

The intent of this section is to characterize the dominant techniques in each of the categories of source control, i.e., input material alteration, technology alteration, and alteration of procedural or institutional settings. The material is largely based on the 22 studies of individual processes and practices, in which over 400 source control techniques were discussed and evaluated. This section also draws from other sources of information, such as Section 6 of this report (Industry Efforts Toward Waste Minimization) and Section 5, Factors That Promote or Inhibit Waste Minimization.

3.1.1 Input Material Alteration

To characterize input material alteration correctly, a distinction must be made between those manufacturing processes that chemically convert or synthesize essentially pure raw materials into a desired product and those that principally remove impurities from the feed to convert it into a useful product or intermediate. An example of the former is ethylene dichloride synthesis through oxychlorination using ethylene, hydrogen chloride, and oxygen; an example of the latter is titanium dioxide produced from ilmenite ore through a chloride process where iron and other impurities are removed to obtain purified titanium dioxide pigment. This distinction is important because input material alteration takes on a different meaning for each type of process.

In the synthesis process, waste can be minimized only to a limited extent by feed material purification (most processes of this type already utilize relatively high purity feed). For example, the use of purer propylene feed in the synthesis of acrylonitrile through ammoxidation of propylene did not result in an observable decrease in byproduct formation (see process study B1). Additionally, achieving a high degree of purification is usually very costly, results in increased energy requirements, and produces wastes in itself.


WASTE MINIMIZATION
RECYCLING
SOURCE REDUCTION
TREATMENT
SOURCE CONTROL
PRODUCT SUBSTITUTION
• Alteration of composition
• Alteration of use
INPUT MATERIAL ALTERATION
• Material purification
• Material substitution
TECHNOLOGY ALTERATION
• Process changes
• Equipment, piping, or layout changes
• Process automation
• Changes to operational settings
• Energy conservation
• Water conservation
PROCEDURAL/INSTITUTIONAL ALTERATION*
• Waste stream segregation
• Procedural measures
• Loss prevention
• Personnel practices

*Also referred to as "good operating practices," "good housekeeping," or "better operating practices" in other parts of report.

Figure 3-1 Elements of Waste Minimization

In the second type of process, where input materials contain a significant amount of impurities, feedstock pretreatment and substitution (i.e., with a higher grade of material) are very effective waste reduction techniques. An example involves the use of higher grade ilmenite with low iron content for titanium dioxide production. There, an ore pretreatment process can be used, which produces marketable iron oxide and higher grade ilmenite. This higher grade ilmenite, in turn, reduces chlorine losses associated with processing lower grade ilmenite directly. Another example involves using lighter feed crude for petroleum refining so as to reduce the amount of impurities requiring removal before processing. In general, the estimated future potential for feedstock pretreatment or substitution remains low, since producers already invest considerable effort to keep the manufacturing cost down by providing the highest possible grade of raw materials to their process.

The above discussion has been limited to the principal raw materials, i.e., those that are converted into the final product. The issue of input material alteration, however, also encompasses auxiliary raw materials. Auxiliary raw materials are those materials that take part in the process but do not become part of the final product. Examples include boiler feedwater treatment chemicals or cooling water treatment chemicals that are encountered in utilities use associated with many processes. Other examples of auxiliary raw materials are process water used to wash the product or intermediate, or a solvent used to wash metal parts in metal surface finishing.

Source control in the area of altering auxiliary raw materials should be oriented primarily toward substituting less toxic or more environmentally acceptable substances for those materials. Thus, aqueous solutions of biodegradable detergents can sometimes be substituted for chlorinated solvents. Similarly, chemical solutions used for equipment cleaning can sometimes be replaced by hydroblasting, which uses only water. Other examples of substitution include use of less toxic trivalent chromium instead of hexavalent chromium in chrome plating, use of aqueous-processable instead of solvent-processable resist in the manufacture of printed circuit boards, or use of nondichromate corrosion inhibitors in cooling water. We have observed that auxiliary materials alteration has a higher potential for future application than the previously described purification of principal raw materials.

3.1.2 Technology Modifications

Generally, technological modifications were found to be the most effective means of reducing waste generation. It was deemed convenient to distinguish the following categories of modifications:

- Process modifications;
- Equipment modifications;
- Process automation;
- Changes in operational settings;
- Water conservation; and
- Energy conservation.

Process modifications or changes, in the context of this study, mean the use of alternative low-waste process pathways to obtain the same product, modification of reaction parameters, or modification of separation parameters. Many times, process modifications will entail subsequent equipment modifications. An example of an alternative process pathway is a chloride route to titanium dioxide, as opposed to a more waste-intensive sulfate route. Another example is the use of screen printing, instead of photolithography, for image transfer in printed circuit board manufacture; this approach eliminates the use of developers. The search for an alternative process pathway usually involves considerable research and development effort and thus may require a long implementation period.

Modification of reaction parameters consists of improvements to catalyst activity, selectivity, and stability; improvements to reactor design; and alteration of reaction pressure and temperature. Modification of reaction parameters is considered to be one of the more exploitable areas in the efforts to reduce process waste generation. Hazardous wastes generated in a chemical conversion process are the result of undesirable side reactions and left over unconverted reactants. These undesirable compounds or wastes are separated from the product downstream of the reactor as part of the product purification step. Typically, the byproducts leave the process as distillation column lights or heavies. Hence, an increase in conversion or yield will decrease both the byproduct formation and/or the amount of unreacted feed. This, in turn, usually results in a lower amount of waste generated. The increase in yield is principally governed by catalyst activity and selectivity, reactor design, and reaction conditions.

Use of a more active and stable catalyst allows for an increase in conversion without the need to provide larger reactor volume; a more selective catalyst allows for inhibition of side-reactions that lead to undesirable byproduct formation. An example of drastic improvement in yield and subsequent reduction in byproduct formation is acrylonitrile synthesis via catalytic ammoxidation of propylene (see process study B1). There, a switch from antimony-uranium catalyst to ferrobismuth phosphomolybdate catalyst in 1972 boosted the conversion (and thus the capacity) by 35 percent. A more recent example is provided by a catalyst for oxychlorination of ethylene to ethylene dichloride in vinyl chloride monomer manufacture. The new catalysts, introduced by the Japanese in 1983, can reportedly produce ethylene dichloride yields comparable to those obtained from direct chlorination. Additionally, since the catalyst is more stable, it maintains its activity over a longer time period. This reduces the waste associated with catalyst changeover and subsequent disposal.

The second important aspect related to reaction parameter modification is the reactor design. Generally, the reactor design is based on kinetic data related to an accepted reaction model. Such data are derived experimentally, usually using bench-scale test apparatus. The reactor design is first performed for the commercial scale reactor, from which the pilot-scale design is derived. The data obtained from the pilot reactor are then used to scale-up the design to commercial size. From the waste generation (or yield) point of view, good reactor design should encompass such factors as:

- Selection of the proper reactor type, i.e., plug flow versus perfectly mixed type;

- Good contact between reactants and catalyst;
- Minimization of local temperature or concentration gradients; and
- Selection of an optimum strategy for reactant addition or temperature trajectory for batch reactors.

An example of how alteration of the reactor design can reduce waste generation is the modification of an allyl chloride synthesis reactor in epichlorohydrin manufacture. By providing better mixing, alteration of reactor design has resulted in a drastic decrease of tar formation. Another example is the development of the fluidized bed catalytic oxychlorination reactor used in vinyl chloride monomer (VCM) manufacture. This reactor design provided better yields than its predecessor, a fixed bed reactor. In phenolic resin synthesis, reactant addition and temperature trajectory can minimize the content of the unreacted phenol present in the post-reactive mixture. The reactant addition and temperature trajectory strategy is generally very important to yield considerations in the design and operation of batch (or plug-flow) reactors.

A related reactor design aspect is rapid quench of the post-reactive mixture. As long as the reactive gas mixture has good contact with the catalyst, side reactions leading to byproduct formation are inhibited. However, when the hot gas leaves the catalytic zone, side reactions may occur and lead to excessive formation of byproducts. Quick cooling, preferably through direct quench, is important in processes such as acrylonitrile synthesis and perchloroethylene-trichloroethylene coproduction. In summary, the reaction parameter alteration is viewed as the principal area for exploration in search for low-waste process routes.

A third area related to process changes is modification of separation process parameters. This approach is illustrated by additional concentration of the bottoms stream leaving a distillation column. This results in less product leaving the process and subsequently in lower waste generation rates. The limitations of this approach may lie in vastly increased energy consumption or physical property limitations, such as viscosity or azeotrope formation. In this context, the use of novel purification/separation techniques (such as supercritical extraction) is considered promising.

Process modification involving concentration of nonrecyclable waste was identified as a subject of considerable controversy throughout the course of the study. The controversy stemmed from the original definition of waste minimization as an activity resulting in a "reduction of total volume of hazardous waste." Under this definition, reduction of the water content of hazardous waste would be viewed as minimization, in spite of a possible increase in the concentration of hazardous or toxic substances. The conflicting viewpoint is that the waste minimization effort should be concerned with reduction of the toxic components in the waste stream, and that a decrease of the water content should not be viewed as a valid waste minimization activity, because it is the equivalent of dilution as a means of decreasing toxicity. This viewpoint corresponds with this study's definition of waste minimization (see Section 1), even though some of the process studies have listed dewatering as a source control technique.

Equipment modifications, as defined in this study, differ from process modifications in that the process function remains unchanged. Waste reduction is accomplished by reducing or eliminating equipment-related inefficiency. An example from the paint manufacturing process is the use of mechanical wall wipers to reduce the amount of paint clinging to the wall of the tank after the batch has been emptied. In this application, the cleaner equipment surface means reduced generation of waste resulting from cleaning of the equipment. Other examples include the use of double mechanical seals on pumps to lower the probability of spillage with the associated cleanup waste and inhibition of heat exchanger fouling deposits by provision of higher turbulence using tube inserts or by provision of smooth heat exchanger surfaces, e.g., electropolished tubes. A related aspect to equipment modification is proper piping and plant layout. Minimizing the length of piping runs, allowance for self-drainage, or designs allowing for "pigging" (i.e., cleaning of pipes using fluid-propelled inserts) all affect the quantity of waste generated.

The relationship of process automation to waste minimization is demonstrated through the following considerations:

- Increased automation means lessening the probability for operator error, which reduces the probability of spills and off-spec product generation; and
- Increased automation can result in higher product yields because of smaller deviations from the set points, or because of on-stream automatic set point optimization.

Examples include automated batching systems, where the manual handling and measuring of substances is replaced by automated closed transfer systems. Such systems can be employed with almost any type of batch operation involving material handling or liquid transfer. In a continuous process, an example of improved automation is a supervisory system that uses a computer to monitor and reset the controller set points automatically to achieve an optimum process performance. The use of a real-time column simulation coupled with automatic set-point adjustment has been applied to a gas/oil desulfurizer fractionator operation in order to maximize product recovery.

Changes in operational settings of equipment involve adjustment to, but not modification of, equipment. An example includes reducing the atomizing air pressure to paint spraying application equipment, which reduces overspray and associated waste. Another example is adjusting the speed of workpiece withdrawal from a cleaning or plating bath. This, in turn, affects the amount of solution remaining on the workpiece (called "drag-out"). Slower withdrawal produces less drag-out, which results in less solution carryover into rinsing and hence reduces the generation of waste treatment sludge. Changes to operational settings in general are easy and inexpensive to implement and often result in substantial reductions in generated wastes.

Energy conservation contributes to minimizing the waste associated with the treatment of raw water, cooling water blowdown, and boiler blowdown, along with the wastes associated with fuel combustion (such as ash or soot). As steam consumption is decreased, raw water requirements are decreased, along with boiler blowdown and cooling water used to condense low-pressure steam. However, it must be noted that an increase in energy conservation is often associated with an increase in the number of heat exchangers used in the process. This may have the undesired effect of increasing the wasteload associated with heat exchanger cleaning. Generally, however, the effect of energy conservation on waste generation is small.

Water conservation can contribute to a reduction of the quantity of the toxic or hazardous components of aqueous waste. For example, if water is used to wash away the soluble impurities from an organic product or semi-product (e.g., ethylene dichloride), the water stream emerging from the wash operation will also be saturated with the product (or semi-product). Although the product would be expected to be insoluble in water, certain losses are inevitable because of small but measurable solubility or physical entrainment. Therefore, reduction in the amount of water used in the wash will also mean reduction of product loss and its carryover into the treatment section. This will subsequently reduce the volume of treatment sludge produced. The individual reductions may be small or may even appear inconsequential; nevertheless, on a total basis, water conservation is expected to have a measurable effect on waste generation. As approaches to source control, water conservation and energy conservation appear to be less important than process changes, equipment changes, increased automation, and changes to operational settings.

In summary, technology modification appears to be a central area of focus for waste minimization. Out of 153 examples of reported source reduction techniques identified in this study, 113 techniques (42 percent) were classified as process/technology modifications (see Section 6). In general, technology modifications are most efficiently addressed during the planning or design period when decisions can be implemented more easily and less expensively, compared to an operational phase which alters existing equipment or processes. It should also be noted that the range of options available to the designer of a new facility is usually considerably wider than the range of available revamp options for an existing plant. In this context, the awareness of the benefits of source control among the process designers (usually licensors and engineering firms) can have a profound impact on the prevention of future hazardous waste generation.

3.1.3 Procedural/Institutional Modifications

This category of source control techniques relates to alteration of procedures or organizational and institutional aspects of a manufacturing operation. For example, proper scheduling of batch operations can have a dramatic effect on waste generated from equipment cleanup. Another example would be the introduction of a new requirement by corporate management that each plant manager be responsible for the periodic reporting of quantity, composition, and disposal costs of every manifested waste leaving his facility, along with the reporting of progress in achieving quantity reduction of such wastes. By itself, this is not a direct waste reduction measure; however, it does raise awareness of the problem within the manufacturing unit and, ultimately, results in activities leading to a reduction of the quantity of waste generated.

Procedural or institutional modifications were termed "good operation practices" (GOP), but also are referred to as "better operating practices" or simply as "good housekeeping." The goal of GOP is to ensure that no additional waste is generated because of human intervention (or lack of it). Based on the information presented in the process and practice studies, GOP is composed of the following elements:

- Employee training;
- Management initiatives;
- Inventory control;
- Waste stream segregation;
- Material handling improvements;
- Scheduling improvements;
- Spill and leak prevention;
- Preventive maintenance; and
- Process documentation.

All of the above elements are essential to an effective GOP program. Without proper employee training and management initiatives, easily solved problems can expand and eventually get out of hand. The simple act of a paint booth operator indiscriminately overspraying the paint will adversely affect waste generation rates and may require both training and intervention of management. The importance of

Inventory control is demonstrated by cases in some industries where the plant management was not truly aware of the actual mass balance and amount of waste generated, because the balances were either not performed or their importance was overlooked. Typically, when management learned of the quantities and the associated disposal costs of wastes produced, corrective action was quickly undertaken.

The practice of segregating wastes has proved beneficial in promoting recyclability of solvents. For example, providing dedicated collection tanks or drums for each type of spent solvent makes the solvents recyclable in that expensive fractional or azeotropic distillation is not required for reclamation; rather, a more commonly used single stage batch still is sufficient. Segregation of hazardous waste streams from nonhazardous waste streams will result in volume reductions of hazardous waste in cases where a mixture of such wastes is classified as hazardous.

Material handling improvements involve, for example, specifying larger containers for storing or containing toxic or hazardous substances. The underlying principle in this option is that the same volume of the substance contacts a smaller surface area in the fewer large containers than in the more numerous smaller containers. This, in turn, results in a smaller leftover amount and a lower probability of spills because of reduced handling. In fact, some companies converted from drums to tote bins, megadrums, or even to bulk handling of certain materials.

Proper scheduling of batch operations is of paramount importance to the resulting equipment cleaning frequency and the associated wasteload. Equipment cleaning waste is often a major waste stream associated with batch operations.

All of the above GOP elements and the remaining ones (preventive maintenance, process documentation, and spill prevention) are discussed in detail in Practice Study B19 in Appendix B.

Based on the process and practice studies prepared for this report, the following observations are made regarding GOP and its application in various industries:

- GOP tends to be more effective for processes characterized by high labor participation (e.g., metal parts cleaning or electroplating);
- GOP tends to be more effective for batch processes (e.g., paint manufacturing or organic dyes and pigments) than for continuous processes (e.g., vinyl chloride monomer production or petroleum refining);
- GOP is generally well accepted, well understood, and the most frequently applied source control technique.

The first two observations are not totally unexpected, considering that labor-intensive processes are subject to higher probability of human error, which results in waste through off-spec product generation, inadvertent spills and leaks, and mixing of hazardous wastes with sanitary wastes.

The third observation is consistent with the common business practice of selecting source control techniques that are obvious, easy, and relatively inexpensive to implement prior to selecting more sophisticated measures. Since GOP is easily implementable, cost effective, and often related to health and safety, current use is high. However, a significant potential for improvement still exists, especially in the area of management initiatives designed to promote waste minimization activities in the firm.

3.2 Current and Future Extent of Waste Minimization through Source Control

In order to fully assess the desirability and proper form of additional government actions designed to promote waste minimization, consideration should be given to the extent to which waste generation has already been minimized and the future extent of additional reductions. The derivation of this estimate was based entirely on the exploratory study of the 22 different waste producing industrial processes and practices contained in Appendix B.

In this study, the current level of waste minimization is estimated using a current reduction index (CRI), a variable directly related to the percent that waste has been reduced compared to the amount that would have been generated if none of the noted source control techniques were in place at their current application level.

The CRI was derived for each technique, every waste stream, and the entire process, based on EPA's analysis of each technique in three categories: effectiveness, extent of current use, and future application potential. The details of how the analyses were developed and transformed into CRI are given in the introduction to Appendix B.

The future potential for waste reduction is characterized in this study by a variable called future reduction index (FRI), which is a measure of possible fractional reduction of the waste currently generated. This reduction would be achieved by implementation of all source control techniques to their full estimated application potential instead of their estimated current application levels. Again, FRI was based on the ratings and the methodology presented in the introduction to Appendix B.

Both CRI and FRI are qualitative estimates of currently achieved and potential future waste reduction. In the index format a scale of 0 to 4 is used; the index can be converted to a percentage by division of CRI or FRI by 4. It should be noted that the indices were devised to be independent of production rates, i.e., they pertain to specific waste generation expressed in pounds of waste per pound of product.

The summary of results obtained for each of the studied processes and practices (with the notable exception of the study of good operating practices where ratings were not developed) is given in Table 3-1.

For all waste streams considered (including both RCRA and non-RCRA streams), the CRIs range from 1.0 to 3.1 (25 to 78 percent). The CRIs indicate that some reductions have already been achieved. It must be noted, however, that such reductions did not occur as a result of actions designed specifically to reduce waste; rather, the minimization of waste was incidental and resulted from the efforts to maximize yields and improve the operating efficiency (see also Sections 2 and 6). It is only recently that waste minimization (and source control in particular) became an area of focused activity, primarily as a result of RCRA regulations leading to significant increases in waste management cost and generator's liability.

Table 3-1 Current and Future Reduction Indices for All Wastes Considered in Process and Practice Studies

SIC Code	Process/ practice	Study number	Number of waste streams	No. of source control methods	Current reduction index (CRI)	Future reduction index (FRI)	
						Probable	Maximum
2491	Wood Preserving	B18	5	20	3.0	0.5	1.6
27	Printing Operations	B12	3	20	2.5	0.7	1.4
2869	Acrylonitrile	B1	4	18	2.0	0.7	1.5
2879	Agricultural Chemicals Formulation	B2	5	8	2.0	1.0	1.2
2869	Epichlorohydrin	B4	5	17	3.1	0.7	0.9
2816	Inorganic Pigments (Titanium Dioxide)	B5	3	7	2.1	0.3	0.5
2865	Organic Dyes and Pigments	B7	5	15	2.4	0.6	1.2
2851	Paint Mfg.	B8	5	20	2.2	0.7	1.7
28128	Phenolic Resins	B10	5	21	1.8	0.7	1.2
2824	Synthetic Fiber Mfg.	B13	3	10	2.3	0.5	0.8
2822	Synthetic Rubber Mfg.	B14	5	17	2.1	0.4	0.8
28692	1,1,1-Trichloroethane	B15	4	13	3.0	0.7	0.8
2869	Trichloroethylene/ Perchloroethylene	B16	6	19	2.3	0.4	0.9
2869	Vinyl chloride	B17	8	31	1.5	0.1	0.3
	Total for SIC 28	--	58	199	2.2(a)	0.6(a)	1.0(a)

Table 3-1 (continued)

SIC Code	Process/ practice	Study number	Number of waste streams	No. of source control methods	Current reduction index (CRI)	Future reduction index (FRI)	
						Probable	Maximum
2917	Petroleum Refining	B9	17	43	2.2	0.5	1.2
3471	Electroplating	B3	4	22	1.8	0.8	1.9
3471	Metal Surface Treatment	B6	5	25	1.0	0.7	1.3
3679052	- Printed Circuit Boards	B11	5	18	2.0	0.7	1.9
N/A	Metal Parts Cleaning	B20	5	20	2.0	1.2	1.9
NA	Equipment Cleaning	B22	2	21	2.6	0.7	1.4
N/A	Paint Application	B21	5	11	1.9	1.1	1.7

NOTES: (a) Arithmetic averages.

Although no specific steps were undertaken in this work to determine the precise chronology associated with each source control technique currently in application, EPA's analysis suggests most of the noted techniques responsible for achieved reduction were probably introduced within the last 15 years.

Table 3-2 lists FRI and CRI derived only for streams containing "F" and "K" RCRA wastes. The individual CRIs and FRIs are similar to those given in Table 3-1, where the compilation was based on both RCRA and non-RCRA streams. This may be indicative of the fact that the reduction of hazardous RCRA wastes is accomplished through application of the same methodology and underlying process principles that are applicable to non-RCRA wastes.

The 22 studied processes/practices provided the basis for nationwide projections of currently achieved and possible waste reductions. The nationwide estimates given in Table 3-3 were computed using the following approach:

- First, the top 12 general industry groups given by two-digit SIC codes were assembled in the order of their fractional contribution to the overall national hazardous waste generation in 1983. The ranking order was adapted from Table 2-3, based on the 1983 CBO data.
- Second, for each two-digit SIC grouping a representative set of processes was selected out of the 22 that were studied. For example, the fabricated metal products group (SIC 34) was represented by electroplating, metal surface treatment, metal parts cleaning, and paint application.
- Third, average CRI and FRI values were computed for each representative set of processes in every group, based on the individual values listed in Table 3-7. For example, the CRI for SIC 34 group was obtained as $(1.8 + 1.3 + 1.6 + 1.9)/4 = 1.6$; i.e., arithmetic average of CRIs for electroplating, metal surface treatment, metal parts cleaning, and paint applications. (The Agency did not have adequate data to produce an average that is weighted for the relative contribution of waste represented by each of the CRI's used to calculate the CRI for a specific SIC group.)
- Fourth, the nationwide CRI and FRI values were obtained by weighting the average group values, by the fraction associated with each group's contribution to the overall waste generation rate. For example, from Table 3-3:

$$\text{CRI} = 0.478 \times 2.7 + 0.18 \times 2.7 + 0.118 \times 2.0 + \ldots\text{etc.} = 2.4.$$

Table 3-2 Current and Future Reduction Indices for "F" and "K" RCRA Wastes Considered in Process and Practice Studies

SIC Code	Process/practice	Study number	Number of waste streams	No. of source control methods	Current reduction index (CRI)	Future reduction index (FRI)	
						Probable	Maximum
2491	Wood Preserving (b)	B18	1	14	3.0	0.5	1.6
27	Printing Operations	B12	1	6	2.0	0.6	1.5
2869	Acrylonitrile	B1	1	8	1.5	0.7	1.5
2879	Agricultural Chemicals Formulation	B2	1	2	2.3	0.8	1.1
2869	Epichlorohydrin	B4	4	13	3.9	0.7	0.9
2816	Inorganic Pigments (Titanium Dioxide)	B5	0	N/A	N/A	N/A	N/A
2865	Organic Dyes and Pigments	B7	1	4	2.3	0.6	1.1
2851	Paint Mfg.	B8	1	9	2.0	0.6	1.7
28128	Phenolic Resins	B10	0	N/A	N/A	N/A	N/A
2824	Synthetic Fiber Mfg.	B13	1	1	3.0	0.3	0.3
2822	Synthetic Rubber Mfg.	B14	0	N/A	N/A	N/A	N/A
28692	1,1,1-Trichloroethane	B15	3	9	3.0	0.7	0.8
2869	Trichloroethylene/ Perchloroethylene	B16	2	11	2.0	0.5	1.0
2869	Vinyl Chloride	B17	3	18	2.9	0.2	0.6
	Total for SIC 28		19	75	2.5(a)	0.6(a)	1.0(a)

Table 3-2 (continued)

SIC Code	Process/ practice	Study number	Number of waste streams	No. of source control methods	Current reduction index (CRI)	Future reduction index (FRI)	
						Probable	Maximum
2917	Petroleum Refining	B9	2	17	1.5	0.6	1.7
3471	Electroplating	B3	3	28	1.8	0.8	1.9
3471	Metal Surface Treatment	B6	2	10	1.3	0.5	0.8
3679052	- Printed Circuit Boards	B11	3	6	2.2	0.7	1.8
N/A	Metal Parts Cleaning	B20	2	7	1.6	1.3	1.7
N/A	Equipment Cleaning	B22	1	21	2.6	0.7	1.4
N/A	Paint Application	B21	3	6	1.9	1.1	1.7

NOTES: (a) Arithmetic averages.
(b) Wood preserving wastestreams are sent to wastewater treatment which generates a RCRA-listed waste.

Table 3-3 National Hazardous Waste Generation and Reduction Profile

SIC Code	Industry	Percent of total waste generation (a)	Waste reduction index (b) Current	Future (probable)	Future (maximum)	Representative process studies Total number	Analog process study numbers (c)
28	Chemical and Allied Products	47.9	2.5	0.6	1.0	9	B1, B2, B4, B7, B8, B13, B15 thru B17
33	Primary Metals	18.0	2.5	0.6	1.0	9	Assumed same as SIC 28
29	Petroleum and Coal Products	11.8	1.5	0.6	1.7	1	B9
34	Fabricated Metal Products	9.6	1.6	0.9	1.5	4	B3, B6, B20, B21
30	Rubber and Plastic Products	5.5	2.6	0.7	1.4	1	B22
39	Miscellaneous Manufacturing	2.1	1.9	0.9	1.4	4	B6, B20, B21, B22
35	Machinery Except Electrical	1.8	1.9	0.9	1.4	4	B6, B20, B21, B22
37	Transportation Equipment	1.1	1.9	0.9	1.4	4	B6, B20, B21, B22
42	Motor Freight Transportation	0.8	1.6	1.3	1.7	1	B20

Table 3-3 (continued)

SIC Code	Industry	Percent of total waste generation (a)	Waste reduction index (b)			Representative process studies	
			Current	Future (probable)	Future (maximum)	Total number	Analog process study numbers (c)
36	Electric and Electronic Machinery	0.7	1.7	0.6	1.3	2	B6, B11
24	Wood Preserving	0.7	3.0	0.5	1.6	1	B18
50	Drum Reconditioning	<0.1	2.6	0.7	1.4	1	B22
	Overall	100.0	2.3(d)	0.6(d)	1.2(d)		

NOTES: (a) Obtained from CBO 1985, see Table 2-3.
(b) Average values for all analog studies listed (based on RCRA stream only, see Table 3-2).
(c) See Appendix B.
(d) Weighted average.

The resulting CRI value is 2.4, which, on the scale of 0 to 4, is equivalent to 60 percent reduction achieved with respect to the waste that would have been currently generated if none of the source control techniques identified were practiced at all. Conversely, this means that if none of these techniques were currently in place, the industry might be generating 1/(1 - 0.6) = 2.5 times as much waste on a "per unit" basis as it does at the present.

The future reduction index (FRI) ranges from 0.7 to 1.3, on the scale of 0 to 4. This suggests a 20 percent reduction might be possible compared to the current waste generation rates if all noted techniques are used to their full estimated potential.

In qualitative terms (which seem to be more appropriate considering that the CRI and FRI both reflect qualitative analyses by EPA), it appears that industry has reduced its "per unit" production waste generation noticably. Furthermore, most of the noted source control methods that are responsible for such reductions appear to have originated through the efforts to decrease the manufacturing costs through increasing yield of chemical conversion, conservation of expensive auxiliary raw material, energy conservation, cost of labor, and increase of overall operation efficiency. Rarely, wastes appear to have been minimized as a result of activities specifically focused on waste minimization. This trend has been observed to occur with increasing intensity since the early 1980s (see Section 6.0).

Although some reduction has occurred, it also is quite clear that further reductions appear feasible. This possibility is supported by EPA's analyses and the simple fact that over 200 million tons of hazardous waste continue to be generated despite all current source reduction.

3.3 Product Substitution

As mentioned previously, product substitution was considered to be a part of source reduction because it has a potential for reducing waste generation at the source. Product substitution is defined as the replacement of an original product with another product intended for the same end use. An example is substitution of wooden pilings with concrete pilings for marine construction, which affects the amount of creosote-treated wood produced and thus the waste associated with its production.

A related area is product conservation or alteration of its end use, where a change occurs in the manner in which the product is used. For example, better tire maintenance by consumers will lower tire replacement frequency, which will subsequently affect production of synthetic rubber and related waste generation.

The area of product substitution or conservation is extremely important, because it affects not only the wastes associated directly with manufacture, but also the wastes associated with the disposal of the used product, which also may pose an environmental problem. This area is also extremely complex because of the need to consider all elements that the feasibility analysis of the proposed substitution entails. The issue involves evaluation of feasibility in four separate areas:

1. Technical feasibility: it must be determined that a substitute will function well in place of the original product and that the replacement frequency is satisfactory;
2. Environmental feasibility: the manufacture and disposal of the substitute product must confer greater environmental benefit (lower overall emissions and/or lower toxicity) than the original product;
3. Socioeconomic feasibility: the incremental costs associated with substitution must be compatible with the net environmental benefits of the substitution. In other words, minor environmental benefits would likely not justify substantially higher costs.
4. Sociopolitical feasibility: where government action is being considered, approaches to promoting the use of a substitute must be found; these approaches must be compatible with the precepts of a free-market economy.

The evaluation of feasibility in all four areas is complex and was deemed to be outside of the scope of this study. However, possible product substitution alternatives were identified for future analytical work. These alternatives are described in detail in Section 10 of each process study provided in Appendix B and also are summarized in Table 3-4.

Table 3-4 Summary of Identified Product Substitutions

Process study	Use of product	Identified substitutes	Remarks
Acrylonitrile (vinyl cyanide)	Manufacture of acrylic and modacrylic fibers	Fabric yardage extension	Precedented in 1973.
Agricultural chemicals formulation	Pest control (insects, diseases, parasites, weeds, etc.)	Integrated pest management	Biological, genetic, "cultural," and chemical control of pests. Not widely implemented because of lack of knowledge of methods, lack of trained IPM personnel, and questionable economic feasibility, and inferior fruit/vegetable appearance.
Electroplating	Protection and cosmetic enhancement of metal surfaces	Zinc plating	Substitute for cadmium plating.
		Titanium dioxide vapor deposition	Substitute for cadmium plating in some applications.
		Aluminum ion vapor deposition	Considerably more expensive than electroplating, but free of hazardous waste.
		Nickel plating	Could replace cosmetic chromium in the absence of consumer opposition.
Epichlorohydrin	Refined: epoxy resins, elastomers	None	Epoxy resins from refined epichlorohydrin are valued for their strength and resistance to chemical attack.
	Crude: synthetic glycerol for cosmetics and drugs	Natural moisturizers, e.g., lanolin; natural glycerol; sorbitol	Natural glycerol is a byproduct of soap manufacture from animal and vegetable fats and oils.
Inorganic pigments (titanium dioxide)	Paint pigment	None	Higher-quality, longer lasting paints could be produced.
	Opacifier for paper products	Alumina or silica clays	These clays are not as bright as titanium dioxide.
Metal surface finishing	Protection and cosmetic enhancement of metal surfaces	Zinc vs. nickel plating	
		Electroless copper vs. nickel	Practiced in the printed circuit board industry.

Table 3-4 (continued)

Process study	Use of product	Identified substitutes	Remarks
Organic dyes and pigments	Coloration of textiles, paints, paper, plastics, printing inks	Disperse dyes Reactive dyes	Growing use due to growth of synthetic fabrics. Wider use depends on development of techniques such as use of fixation accelerators, short-liquor dyeing, or low-temperature dyeing.
Synthetic fibers	Acrylic, nylon, olefin, and polyester fibers	Natural fibers	New finishing techniques are required to give natural fibers the desirable properties of synthetic fibers.
Synthetic rubber	Vehicle tires and other uses	Natural rubber	Synthetic rubber use could decline by using radial tires, which require more natural rubber.
		Ethylene-propylene rubber (EPR)	Though a synthetic rubber, wider use of EPR can reduce waste because of its relatively low fractional waste loads. Synthetic rubber use can be reduced through practices which reduce tire replacement frequency.
1,1,1-Trichloroethane	Solvent for vapor degreasing and cold cleaning operations	Recycled 1,1,1-TCE Water-soluble synthetic cleaners	The prospects for product substitution are best for recycled 1,1,1-TCE. Water-soluble cleaners require changes in cleaning practice.
Trichloroethylene/ perchloroethylene	Principal solvents for cleaning operations	1,1,1-trichloroethane (1,1,1-TCE)	1,1,1-TCE is less toxic.
		Petroleum solvents	Petroleum solvents are used in dry cleaning operations, but are highly flammable.
		1,1,2-trichloro-1,2,2-trifluoroethane	This solvent is little used because of high cost and a need for work environment control.
		Alkaline cleaning fluid	Combined with ultrasonic equipment, alkaline cleaning fluid can remove oil residues.
Vinyl chloride	Manufacture of polyvinyl chloride (PVC) and its copolymers	Clay, cast iron, ductile steel	These materials have large-diameter piping applications and can replace PVC there.
		Aluminum	Aluminum can be used in irrigation piping applications to replace PVC.

Table 3-4 (continued)

Process study	Use of product	Identified substitutes	Remarks
Wood preserving	Preservation of railroad ties, utility poles, and pilings	Steel-concrete substitutes	Steel-concrete substitutes cost considerably more than wood.
Paint manufacture	Coatings for architectural structures	Brick, marble, glass, colored concrete, anodized metal siding, vinyl-coated siding	Exterior architectural applications.
		Wood paneling, fabric coverings, wallpaper	Interior architectural applications.
	Coatings for functional and cosmetic enhancement of products	Powder coatings, plastic coatings	Product coating applications.
		Yel'ow iron oxide, organic pigments	Chrome yellow is still required in traffic paint.
Petroleum refining	Gasoline, kerosene, distillate, and residual fuel oils for use as fuels, plus other crude petroleum products	Solar, nuclear, coal energy; gasohol and methanol	Alternative energy sources have limited economic practicability relative to petroleum sources.
Phenolic resins	Binding resins, tackifiers, and insulation (phenolic foam) for plywood, granulated wood, moldings compounds, laminates, spun insulation, foundry binders, abrasives, protective coatings	Injection-molded thermoplastics	These can serve as substitutes for phenolic resin binders in the manufacture of waferboards.
		Thinner laminates, low-pressure polyester or melamine laminates	
		Epoxy or silicon resins	
		Pine from the Pacific Northwest	Pine from the Pacific Northwest is less absorbent than Southern pine.
Printed circuit boards	Business machines, computers, home entertainment and communications equipment	Surface mounting, reduction of board size	Product reconfiguration eliminates some plating steps and reduces waste generation from other cleaning, plating, and photoresist stripping steps.
		Use of injection-molded thermoplastics	

Table 3-4 (continued)

Process study	Use of product	Identified substitutes	Remarks
Printing operations	Printed matter using heat-set solvent-base inks, and plates and films containing silver	Water-borne inks (used currently in gravure and flexographic printing)	Water-borne inks require more energy to dry, require brief process stoppages, possess a low gloss, and cause paper curl.
		Utraviolet (UV) inks	UV inks are 75 to 100 percent more expensive than heat-set inks, and papers that contain them cannot be deinked by conventional methods. UV lighting is hazardous to personnel, and UV light acting on oxygen creates ozone.
		Electron-beam-dried (EB) inks	EB inks can be created from UV inks. Electron beams cause x-rays and paper degradation.
		Heat-reactive inks	Heat-reactive inks have less than 20 percent of volatile content of heat-set inks, but cannot be used in sheet-fed processes and can permit buildup of static electricity.
		Electrostatic screen printing	

Finally, it must be noted that of all the source reduction techniques discussed, product substitution is the most controversial. Industry generally viewed the inclusion of product substitution as part of waste minimization as inappropriate, because they perceive it as leading to government intrusion into the free marketplace.

3.4 Summary of Findings and Observations

Observation #1

Until recently, (prior to the 1980s) waste minimization was rarely directly addressed by industry, i.e., it was rarely pursued as a separate and specific project objective. Rather, waste minimization occurred mainly as a result of efforts to decrease manufacturing costs through improvement of yields and operating efficiency.

Observation #2

Because of implementation of the various source control techniques discussed in Appendix B, the level of waste generation in terms of units of waste per unit of product may have declined significantly in the last 15 years (the time frame during which most of the noted techniques have been applied). If none of these techniques were in place today, industry might be generating as much as 2.5 times more waste per unit of product than it does at present. This figure is based on qualitative and preliminary information and should not be considered definitive.

Observation #3

The potential for future reduction of waste generation appears to be significant. The estimates range from 18 to 33 percent reduction of unit of waste per unit of product compared to the current level of waste generation. These reductions would result from the extension of existing source control techniques and the application of new technologies identified in Appendix B to their fullest potential. The time scale over which these reductions may take place was not estimated; however, it appears unlikely that a period would exceed 25 years.

Observation #4

Waste minimization through further extension of good operating practices appears most promising in the industries characterized by high labor utilization, or where batch processing is used. Additional implementation of good operating practices will probably have only limited effect on waste generation in large-scale continuous processes with a relatively high degree of automation.

Observation #5

For continuous processes generating large amounts of waste, the most promising area for source control is technology modification. Input material alteration is most effective in those processes where impurities constitute a considerable fraction of input materials or where the potential exists for lowering the toxicity of the auxiliary raw material.

Observation #6

Energy conservation contributes to a lowering of waste generation from utilities serving the production process. However, it may produce additional wasteloads associated with periodic cleaning of added heat transfer equipment.

Observation #7

The approach of reducing the water content of hazardous waste to obtain "volume reduction" does not appear worthy of classification as a valid waste minimization technique. It is viewed as a reverse equivalent of dilution as a means of reducing toxicity. However, conservation of water can contribute to a limited extent to reduction of waste generation in cases where water is in contact with the organic phase. This is because the carryover of organics into the treatment section is lessened, together with the related sludge output. Waste resulting from raw water treatment can be reduced through water conservation efforts. In certain cases, the wastewater treatment sludge can also be reduced, e.g., the sludge resulting from coprecipitation of toxic metal hydroxides together with the calcium and magnesium hydroxides.

Observation #8

In a chemical process, catalyst use and reactor design appear to have the strongest potential impact on waste generation. Improved catalyst selectivity, along with optimum reactor design (or reaction strategy, such as temperature trajectory for batch reactors), directly affects the amount of byproduct formation. The byproducts form a waste stream which typically exits the process in the separation section, e.g., as distillation column bottoms. Advances in catalysis science and application together with advances in kinetics and applied reactor design methodology have been particularly intensive in the last 15 years.

Because catalyst and reactor characteristics are often critical to product yield, (and thus to the profitability of the operation), they are usually considered proprietary.

Observation #9

Product substitution is an extremely complex and sensitive issue. Full assessment of any product substitution alternative must address, at the very least, the following issues:

- Technical feasibility -- i.e., a substitute must provide the same function as or better function than an original product.
- Environmental feasibility -- i.e., comparison of wastes and emissions associated with the substitute's manufacture and disposal to that of the original product must clearly favor the substitute.

Both quantity and type of wastes and emissions should be considered, along with the comparative lifetimes of the original product and its proposed substitute. In addition, these substitutions should be feasible from a socioeconomic standpoint (increased costs compatible with net environmental benefit). Finally, where direct government intervention is involved, implementation approaches should not violate the principles governing the functioning of a free market economy.

4. WASTE RECYCLING PROFILE

This chapter discusses both the concept and practice of recycling hazardous wastes in the United States. The focus of this chapter is on a characterization of recycling practices including identification of participating industries, waste streams recycled, and frequently employed recycling technologies. Offsite recycling options and the future extent of recycling are also discussed.

Section 4.1 presents a brief characterization and examples of waste recycling practices. Section 4.2 addresses patterns of recycling in the United States. This information is presented in three ways: industry-specific, waste stream-specific, and technology-specific. The industry-specific section summarizes the recycling activities of the ten highest volume hazardous waste generators and discusses recycling by small quantity generators as a class. The waste-specific section discusses the types and volumes of waste streams that are recycled and those for which there is limited or no potential for recycling. The technology-specific section includes a discussion of the more commonly used recycling technologies for various categories of wastes, the costs associated with each category, and the uses of the recycled products.

Section 4.3 describes the factors involved with offsite recycling. The options discussed in this section include commercial recycling facilities, waste exchanges, information exchanges, material exchanges, and other cooperative offsite recycling arrangements.

Section 4.4 discusses the future extent of recycling from an economic point of view. This includes a discussion of the incentives for recycling produced by the Hazardous and Solid Waste Amendments of 1984 (HSWA) and other economic factors such as projected increases in feedstock and fuel costs, raw material shortages, foreign competition, and new technologies.

4.1 Characterization of Recycling Practices and Technologies

Recycling of waste materials can be characterized by three major practices (1) direct use or reuse of the material in a process, (2) reclamation by recovering secondary materials for a separate end use (e.g., recovery of metal from sludge material), and (3) removing impurities from a waste to obtain a relatively pure, reusable substance (e.g, removal of impurities from a cyanide plating bath solution results in a bath that can be reused). The current extent of recycling of hazardous waste by U.S. industries appears to be minor in comparison with other waste management practices. Less than five percent of hazardous waste generated in 1981 was reported to be recycled or reused (RIA Mail Survey, generators 1981).

This pattern of recycling has both industry-specific and waste-stream specific components. Some major industries are more likely to recycle than others; that is, they recycle a substantially larger fraction of the waste they generate. Within an industry category, some wastes are more likely to be recycled than others (e.g., solvents more than pesticides), and the patterns of onsite and offsite recycling vary with the size of the industry and the waste stream generated.

The pattern of recycling in the United States is in fact predominantly an onsite waste management practice, accomplished either by using the waste directly without prior processing or by reclaiming the waste to recover constituent materials that then can be used directly. Eighty-one percent of the volume of hazardous waste recycled by U.S. industry in 1981 (the RIA Mail Survey study year) was performed onsite. However, the profile of recycling in the United States is changing to include offsite commercial recycling operations and direct transfers of waste from generator companies to others who can reuse the waste.

Waste streams that are recycled directly are those that can be used as ingredients or feedstocks in a production process or as an effective substitute for a raw material. Examples of recovery of a product to be returned to a process include (1) the distillation and reuse of solvents as equipment cleaning fluids by offsite commercial operations and (2) the recycling of pesticide dusts collected in bag filters during product formulation (an onsite recycling operation). Ferric chloride waste from the titanium dioxide manufacturing process (chloride route) is reused as a feedstock in water treatment, thus serving as an effective substitute for a raw material in another process.

In order to be reusable, recycled wastes must have the functional properties of the virgin material. Waste streams that are high in impurities or that are not amenable for direct reuse must be processed to recover the materials of value. Some wastes can be recycled only after their hazardous constituents are removed. The type of reclamation processes used are dictated by the type of waste and the nature of contamination. Reclamation processes fall into the following categories:

- Chemical separation (e.g., distillation);
- Physical separation (e.g., ultra filtration and reverse osmosis); and
- Electrochemical separation (e.g., electrolysis).

Manufacturing byproducts or secondary recovery products also may be reclaimed from process wastes. One example is the recovery of hydrochloric acid by scrubbing of combustion gases during thermal destruction of chlorinated organic wastes. The recycling value of organic wastes may also include thermal energy recovered during combustion, if 60 percent of the potential energy in the waste is recovered as heat and 75 percent of the recovered heat is actually used (40 CFR 261.6).

4.2 Current Extent of Recycling

This section examines the occurrence of hazardous waste recycling according to the type of industry that generated the recycled waste, and also according to the types of waste streams recycled. A brief sketch of available recycling technologies and their relative costs is presented.

4.2.1 Industry-Specific Profile

The pattern of recycling in the United States varies with the type and size of the industries involved. The industry-specific profile below characterizes recycling by U.S. industries according to the fraction of each industry's waste that is recycled and the distribution among industries of the total volume of waste that is recycled. Patterns of recycling that are unique to small quantity generators are identified. This information was derived largely from the RIA Mail Survey data base and from an analysis of those data by Westat (1984). Additional data on recycling by small generators were obtained from the 1984 National Small Quantity Hazardous Waste Generator Survey (Ruder et al. 1985).

Of the 42 billion gallons (159 billion metric tons) of hazardous waste generated by U.S. industries in 1981 (RIA Mail Survey, generators 1981), 1,575 million gallons (6 million metric tons) or approximately 4 percent were recycled. Table 4-1 lists the volumes of hazardous waste generated and recycled in 1981 by the ten highest volume hazardous waste generators, subdivided into the fractions recycled onsite or offsite. The volume recycled offsite by each industry is further divided into (1) the volume of wastes recycled offsite by the same firm that generated the wastes and (2) the volume recycled offsite by other firms. Note that Table 4-1 does not reflect the volumes of wastes handled by management practices other than recycling. These data suggest that the volume of waste recycled onsite by a generator increases with the total volume of waste recycled. That is, industries that recycle large volumes of wastes are more likely to do so onsite than offsite.

Figure 4-1 illustrates the information provided in Table 4-1. Among the high volume generators, there is a notable variance from the average of 4 percent of waste recycled for all SICs. The Transportation Equipment industry (SIC 37) recycled 900 M gals, 39 percent of their total waste, over twice the volume of the largest generator (Chemicals and Allied Products industry (SIC 28) at 340 M gals (1.2 percent) recycled). This pattern is consistent with the types of waste generated during motor vehicle manufacture, namely, metal cleaning (degreasing) wastes, electroplating wastes, and other product fabrication wastes. These wastes are often dilute and uniform in constituents, and, therefore, may be easier to reprocess than many of the organic sludges and still bottoms generated by the Chemical and Allied Products industries (SIC 28). Of the remaining high volume generators, only the Motor Freight Transportation and Warehousing industry generators did not report recycling some portion of hazardous waste generated. In actuality, although some spent halogenated and nonhalogenated solvents generated by SIC 42 industries were recycled at TSD facilities during 1981, no SIC 42 generators reported recycling of their hazardous wastes in the RIA Generator Mail Survey.

Table 4-1 Ten Highest Volume Waste Generating Industries – Generation and Recycling Volumes During 1981

SIC	Industry	Volume of waste generated M gals	Total volume recycled M gals	Total volume recycled (Percent[a])	Volume recycled onsite M gals	Volume recycled onsite (Percent[a])	Volume recycled offsite M gals	Volume recycled offsite (Percent[a])	Volume recycled offsite by same firm M gals	Volume recycled offsite by same firm (Percent[a])	Volume recycled offsite by other firm M gals	Volume recycled offsite by other firm (Percent[a])
28	Chemicals and Allied Products	28,000	340	(1.2)	300	(1.1)	32	(0.1)	0.4	(< 0.1)	31	(0.1)
35	Machinery – Except Electrical	4,200	26	(0.6)	18	(0.4)	7.9	0.2	< 0.1	< 0.1	7.9	(0.2)
37	Transportation Equipment	2,300	900	(39)	880	(38)	22	(0.9)	NR*		22	(0.9)
42	Motor Freight Transportation	1,700	NR*		NR*		NR*		NR*		NR*	
29	Petroleum and Coal Products	1,300	36	(2.8)	32	(2.5)	4.2	(0.3)	0.2	(< 0.1)	4.0	(0.3)
33	Primary Metal Industries	1,000	170	(17)	18	(1.8)	150	(15)	NR*		150	(15)
17	Construction – Special Trade Contractors	870	0.2	(< 0.1)	0.1	(< 0.1)	0.1	(< 0.1)	NR*		0.1	(< 0.1)
34	Fabricated Metal Products	820	24	(2.9)	14	(1.7)	9.6	(1.2)	0.9	(0.1)	8.7	(1.1)
36	Electric and Electronic Equipment	670	47	(7.0)	0.4	(0.1)	46	(6.9)	< 0.1	< 0.1	46	(6.9)
49	Electric, Gas, and Sanitary Services (includes POTWs)	470	3.3	(0.7)	0.1	(< 0.1)	3.2	(0.7)	< 0.1	(< 0.1)	3.2	(0.7)

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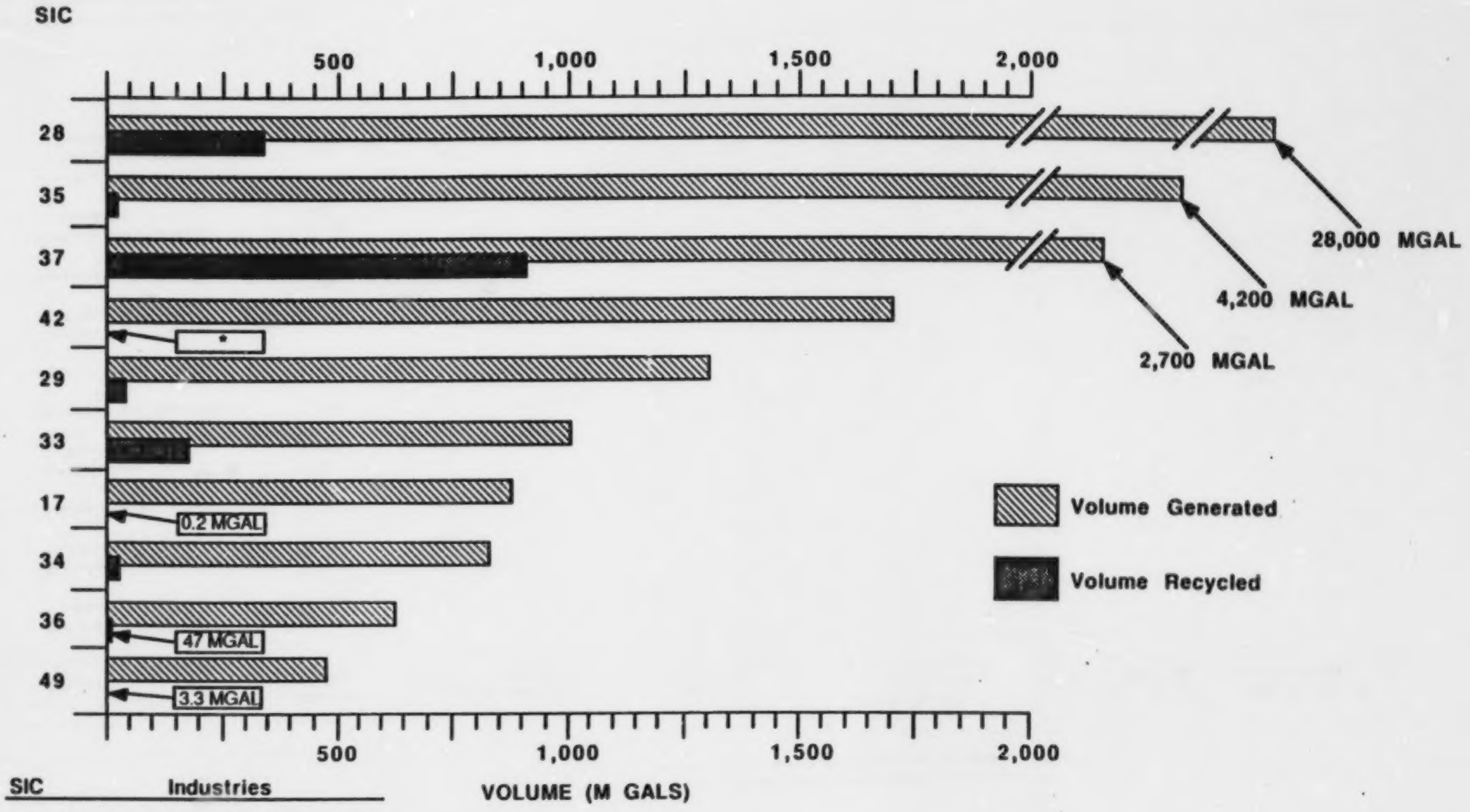
[a] Percent of total waste generated (by SIC).

Source: RIA Generator Survey data.

NR* – No recycling of this type reported in RIA Generator Survey.



SIC	Industries
28	Chemicals and Allied Products
35	Machinery, Except Electrical
37	Transportation Equipment
42	Motor Freight Transportation
29	Petroleum and Coal Products
33	Primary Metal Industries
17	Construction, Special Trade Contractors
34	Fabricated Metal Products
36	Electric and Electronic Equipment
49	Electric, Gas and Sanitary Services

Source: RIA Generator Survey

* No recycling by generators was reported in RIA Generator Survey.

Figure 4 - 1 Comparison of Volume Generated and Volume Recycled in 1981 by the Ten Highest Volume Hazardous Waste Generating Industries

Figure 4-2 illustrates the percentage of the total volume of hazardous waste generated that was recycled during 1981 by individual SICs. Three manufacturing industries, the Transportation Equipment industry (SIC 37), the Chemicals and Allied Products industry (SIC 28), and the Primary Metals industry (SIC 33), accounted for 89 percent of the total volume of hazardous waste recycled in the United States in 1981 (RIA Mail Survey, generators).

Small Quantity Generators (SQGs)

Offsite recycling accounted for the disposition of approximately 65 percent of the hazardous waste generated by SQGs during 1984. Another 6 percent was estimated to be recycled onsite (Ruder et al. 1985). (These numbers reflect an overlap with other management practices including onsite disposal in public sewers, waste treatment, and offsite disposal.)

Recycling is favored by SQGs over disposal for wastes shipped offsite (Ruder et al. 1985). Those SQGs generating more than 100 kg/month of hazardous waste were more likely to recycle their wastes than the smaller SQGs. Furthermore, the larger the volume of waste generated by the SQG, the more likely it was that the waste was shipped offsite (Ruder et al. 1985). These data suggest an inability or unwillingness of SQGs to manage large volumes of waste onsite. This pattern for SQGs is unlike that observed for large quantity generator industries that are more likely to recycle larger volumes of wastes onsite than offsite (see Table 4-1).

4.2.2 Waste-Specific Profile

The distribution of hazardous waste recycling as a function of the waste stream may be calculated either from the total volumes of waste streams recycled or from the constituent concentrations of those waste streams.

The following distribution of the total volume of waste recycled during 1981 is based on volume data recorded for five major hazardous waste categories:

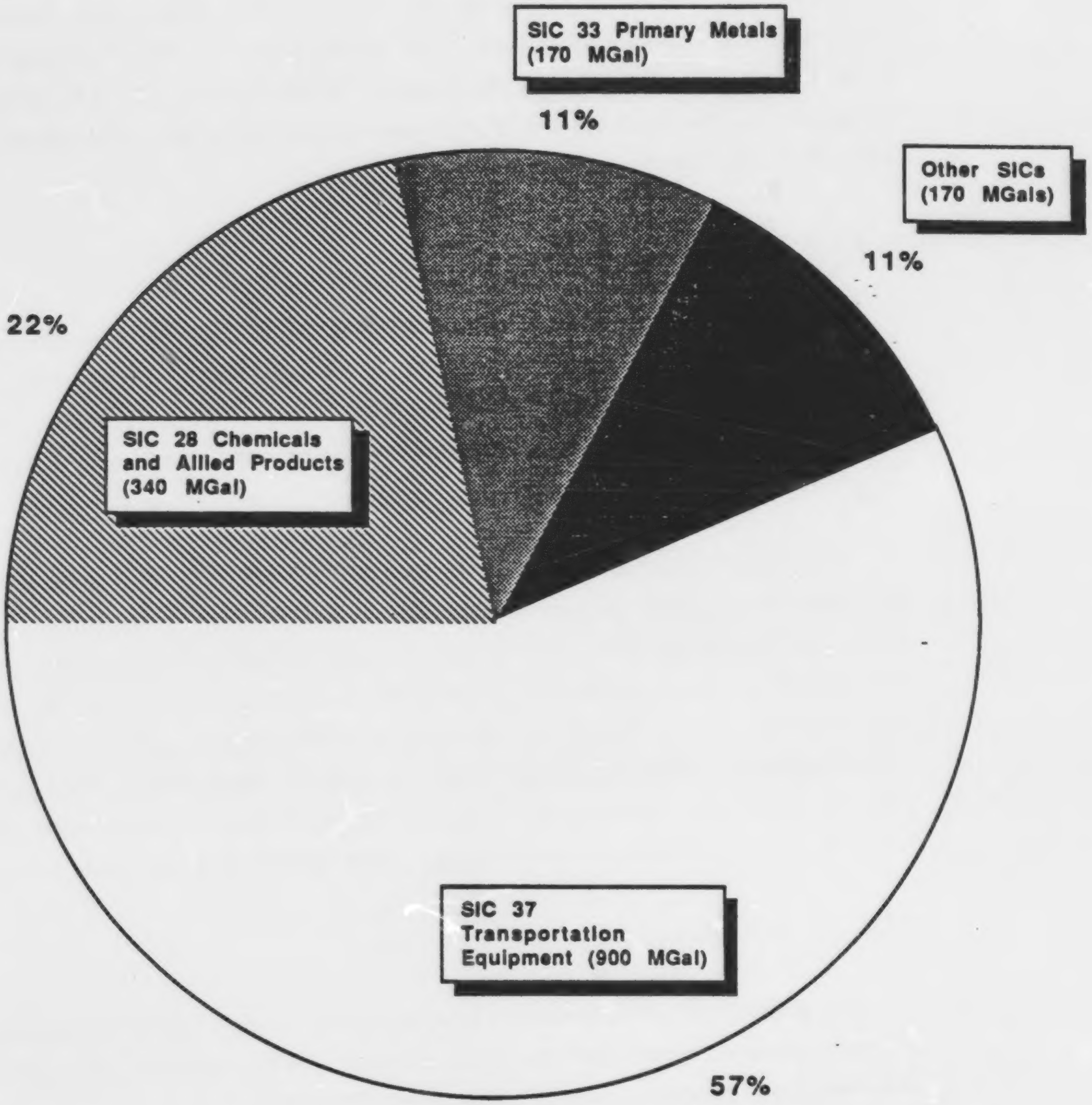


Figure 4-2 Distribution of the Total Volume* of Hazardous Waste Recycled During 1981, by SIC Category

Source : RIA Generator Survey

*Total Volume of Hazardous Waste Recycled in 1981 was 1580 M Gal

Waste Categories

24%	Solvents (halogenated and nonhalogenated)
<0.1%	Halogenated (nonsolvent) waste
28%	Metal-bearing wastes
29%	Corrosive wastes
20%	Cyanide reactive wastes
100%	

Some wastes have characteristics of more than one waste category. For example, the volume of metal-bearing wastes is underestimated because pickle liquor is included (for the purposes of counting) as a corrosive waste rather than a metal-bearing waste.

More detailed volume data on specific waste streams are presented in Table 4-2, which lists the highest waste volume for each of the five major waste categories that were recycled during 1981 either onsite or offsite. These waste streams are identified by RCRA waste codes (40 CFR 261.31) and, in some cases, by mixture codes (e.g., X001). The mixture codes were developed by Westat (1984) to describe waste streams consisting of mixtures of two or more RCRA wastes.

Waste streams recycled onsite during 1981 in volumes higher than or equal to 100 M gal included:

- D007 - chromium waste;
- D002 - corrosivity characteristic waste; and
- F006 - wastewater treatment sludges from electroplating operations (classified as a cyanide/reactive waste).

The only waste recycled offsite in a volume higher than 100 M gal was K062 - pickle liquor (classified as a corrosive waste). These four wastes account for 49 percent of the total volume of waste recycled in 1981 (excluding wastes for which no RCRA waste code was given).

Large volume metal-bearing waste streams (excluding pickle liquor) that were recycled during 1981 were handled offsite. Such wastes are typical of plating solutions, rinse waters, and sludges generated and recycled by the Transportation Equipment (SIC 37) and Primary Metals (SIC 33) industries. Slop oil emulsion solids

Table 4-2 Wastes Recycled During 1981

Description of waste stream	WESTAT waste code[1]	RCRA waste code	Volume recycled onsite (mgal)	(%)	Volume recycled offsite (mgal)	(%)	Total volume recycled (mgal)	Waste category				
								Solvents	Halogenated (nonsolvent) organics	Metals	Corrosives	Cyanide/ reactives
Solvent wastes												
Spent nonhalogenated solvents		F005	84	(86)	13	(14)	97	X				
Ignitable solid waste		D001*	37	(58)	26	(42)	63	X				
Spent halogenated solvents used in degreasing		F001	10	(24)	32	(76)	42	X				
Spent nonhalogenated solvents		F003	(0.1)	(0.1)	17	(99.9)	17	X				
Spent nonhalogenated solvents	X002	mixture F003, F005	5.4	(40)	8	(60)	14	X				
Heavy ends form the distillation of ethylene dichloride in ethylene dichloride production		K019	NR		4		4	X				
Spent halogenated solvents	X001	mixture F001, F002	0.1	(2)	3.1	(98)	3.2	X				
Spent halogenated and nonhalogenated solvents	X018	mixture F002,F003,F005	1.0	(32)	2.2	(68)	3.2	X				
Heavy ends from distillation of ethylene dichloride (ethylene dichloride production); heavy ends from distillation of vinyl chloride (vinyl chloride monomer production)	X084	mixture K019, K020	NR		2.5		2.5	X				
Acetone		U002	1.8	(78)	0.5	(22)	2.3	X				
Ethyl acetate		U112	0.2	(77)	(0.1)	(23)	0.2	X				
Metal-bearing wastes												
Chromium		D007	470	(99)	0.3	(0.1)	470			X		
Lead		D008	32.0	(66)	17	(34)	49			X		
Slop oil emulsion solids (petroleum refining)		K049	40	(98)	0.8	(2)	40			X		
Dissolved air flotation float (petroleum refining)		K048	35	(97)	0.9	(3)	36			X		
Emission control dust/sludge from primary production of steel in electric furnaces		K061	11	(38)	18	(62)	29			X		
Emission control dust/sludge from secondary lead smelting		K069	5.6	(56)	4.5	(44)	10			X		

Table 4-2 (continued)

Description of waste stream	WESTAT waste code[1]	RCRA waste code	Volume recycled onsite (mgal)	(%)	Volume recycled offsite (mgal)	(%)	Total volume recycled (mgal)	Waste category Solvents	 Halogenated (nonsolvent) organics	 Metals	 Corrosives	 Cyanide/ reactives
Metal-bearing wastes (continued)												
Mixture of barium, cadmium, chromium, lead, and mercury	X039	mixture of D005,D006, D007,D008,D009	9.5		NR		9.5			X		
API separator sludge from petroleum refining; hexavalent chromium and lead		K051	7.2	(96)	0.3	(4)				X		
Ignitable solid waste		D001*	4.3	(90)	0.5	(10)	4.8			X		
Washes and sludges from ink formulation		K086	<0.1	(<1.0)	2.4	(99)	2.4			X		
Halogenated (nonsolvent) organics												
Untreated process wastewater from production of toxaphene		K098	0.22		NR		0.22		X			
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer)		D013	NR		0.1		0.1		X			
Chlordane, tech.		U036	NR		<0.1		<0.1		X			
p-Dichlorobenzene		U072	<0.1		NR		<0.1		X			
Heptachlor		P059	NR		<0.1		<0.1		X			
Pentachlorophenol	P090	F027	<0.1	(20)	<0.1	(80)	<0.1		X			
DDT		U061	NR		<0.1		<0.1		X			
Corrosive wastes												
Corrosivity-characteristic solid waste (not listed in Subpart D)		D002	270	(88.5)	35	(11.5)	305				X	
Spent pickle liquor (steel finishing operations)		K062	28	(9.8)	260	(90.2)	290				X	
Ignitable solid waste		D001*	71		NR		71				X	
Sulfuric acid, thallium salt (I)		P115	NR		1.6		1.6				X	
Cresylic acid	U054	U052	NR		1.2		1.2					

Table 4-2 (continued)

Description of waste stream	WESTAT waste code[1]	RCRA waste code	Volume recycled onsite (mgal)	(%)	Volume recycled offsite (mgal)	(%)	Total volume recycled (mgal)	Waste category Solvents	Halogenated (nonsolvent) organics	Metals	Corrosives	Cyanide/ reactives
Reactive characteristic waste		D003*	0.7		NR	0.7	0.7				X	
Corrosivity characteristic waste containing lead	X052	mixture of D002, D008	0.4		NR	0.4	0.4				X	
Chrysene		K050	0.3	(99)	(0.1)	0.3	0.3				X	
Bis (2-ethylhexyl) phthalate		U028	NR		0.1	0.1	0.1				X	
Cyanide/reactives												
Wastewater treatment sludges from electroplating operations		F006	430	(96)	19	(4)	449					X
Reactive characteristic waste		D003*	18	(98)	0.3	(2)	18					X
Spent plating bath solutions from electroplating operations		F007	3.3	(72)	1.3	(28)	4.6					X
Spent stripping and cleaning bath from electroplating		F009	0.6	(33)	1.1	(67)	1.7					X
Ammonia still lime sludge from coking		K060	1.3		NR		1.3					X
Sodium cyanide		P106	NR		0.5		0.5					X
Still bottoms from final purification of acrylonitrile		K012	0.2		NR		0.2					X
Plating bath sludges from electroplating		F008	0.1	(24)	0.2	(76)	0.3					X
Cyanides		P030	<0.1	(80)	<0.1	(20)	<0.1					X
Ignitable solid waste		D001*	NR		0.1		0.1				X	

[1]Source: RIA Mail Survey (TSD and Generator Surveys).

*Listed in more than one waste category.

NR = Not reported.

and other metal-bearing wastes from petroleum refining (SIC 29) were also recycled onsite. Metal wastes recycled offsite were K061 (emission control dust/sludge from primary production of steel in electric furnaces) and K086 (washes and sludges from ink formulation).

Wastewater treatment sludges from electroplating operations (F006) account for over 90 percent of the volume of cyanide/reactive waste recycled during 1981. Reactive characteristic wastes (D003) and spent plating bath solutions from electroplating operations (F007) account for another 9 percent of the cyanide/reactive wastes recycled. Ninety-five percent of recycled cyanide/reactive wastes were managed onsite.

During 1981 the Chemicals and Allied Products industries (SIC 28) recycled 74 percent of the total halogenated and nonhalogenated solvents that were recycled in that year (RIA Mail Survey); 65 percent were SIC 28 wastes recycled onsite and another 9 percent were SIC 28 wastes recycled offsite (RIA Mail Survey). The metal finishing industries (SICs 33 to 37) recycled another 22 percent of the solvent wastes that were recycled, with an even distribution between onsite and offsite recycling. The relatively low volume of halogenated (nonsolvent) organics recycled can be explained by the low recovery value of those wastes. Of the halogenated (nonsolvent) organic wastes that were recycled, 48 percent were recycled onsite and 52 percent were recycled offsite (RIA Mail Survey).

Ignitable solid waste (D001), distributed among the solvent, metals, and corrosive waste categories, accounted for almost 5 percent of all waste streams reported to be recycled during 1981. Approximately one-half of all recycled ignitable solid wastes reported were solvents. Although the constituents of these waste streams were not reported in the RIA Mail Survey, it is known that reclamation still bottoms and other unrecyclable solvent wastes are used for heat recovery in industrial boilers.

A waste-specific profile of recycling may also be drawn from examination of the constituent concentrations of hazardous waste streams managed by various practices. Weighted average concentrations of constituents in waste streams managed by recovery/reuse (recycling) practices were calculated from data stored in EPA's Industrial Studies Data Base (ISDB). (Appendix A provides a description of this data base.) These data, which represent management practices of the Chemical and Allied Products (SIC 28) industries only, are illustrated in Figures 4-3 through 4-9. The weighted average concentration is calculated by the following equation:

$$C_W=[\Sigma(C_c-C_v)]/\Sigma C_v$$

Where

C_W = weighted average concentrations;
C_c = constituent concentration (weight %); and
C_v = constituent waste stream volume.

The figures illustrating the management of waste streams that contain halogenated and nonhalogenated solvents, halogenated organics, corrosives, or cyanide/reactive wastes (Figures 4-4, 4-5, 4-8, and 4-9, respectively) indicate that the higher the weighted average concentration of those constituent wastes in a waste stream, the more probable the selection of recovery/reuse as a management option. The difference between the weighted average concentrations of corrosive (Figure 4-8) or cyanide/reactive (Figure 4-9) wastes managed by recovery/reuse and other management options was less than 5 percent. These suggest a threshold level for recycling between 1 and 5 percent weighted average concentration for those constituent wastes. Nonhalogenated solvents have a similar profile, with an apparent threshold level for recycling between 1 and 9 percent weighted average concentration.

The weighted average concentrations for constituent halogenated solvent wastes (Figure 4-5) and halogenated organic wastes (Figure 4-7) that are recovered/reused are much higher (37 to 42 percent) than those of nonhalogenated wastes and much higher than the weighted average concentrations of halogenated waste streams managed by other practices. Metal constituent waste streams (Figure 4-6) apparently are not handled in any substantial volume by the SIC 28 industries. The weighted metal constituent concentrations of waste streams managed by any practice in SIC 28 are, according to the ISDB data, several orders of magnitude lower than those values for other constituents.

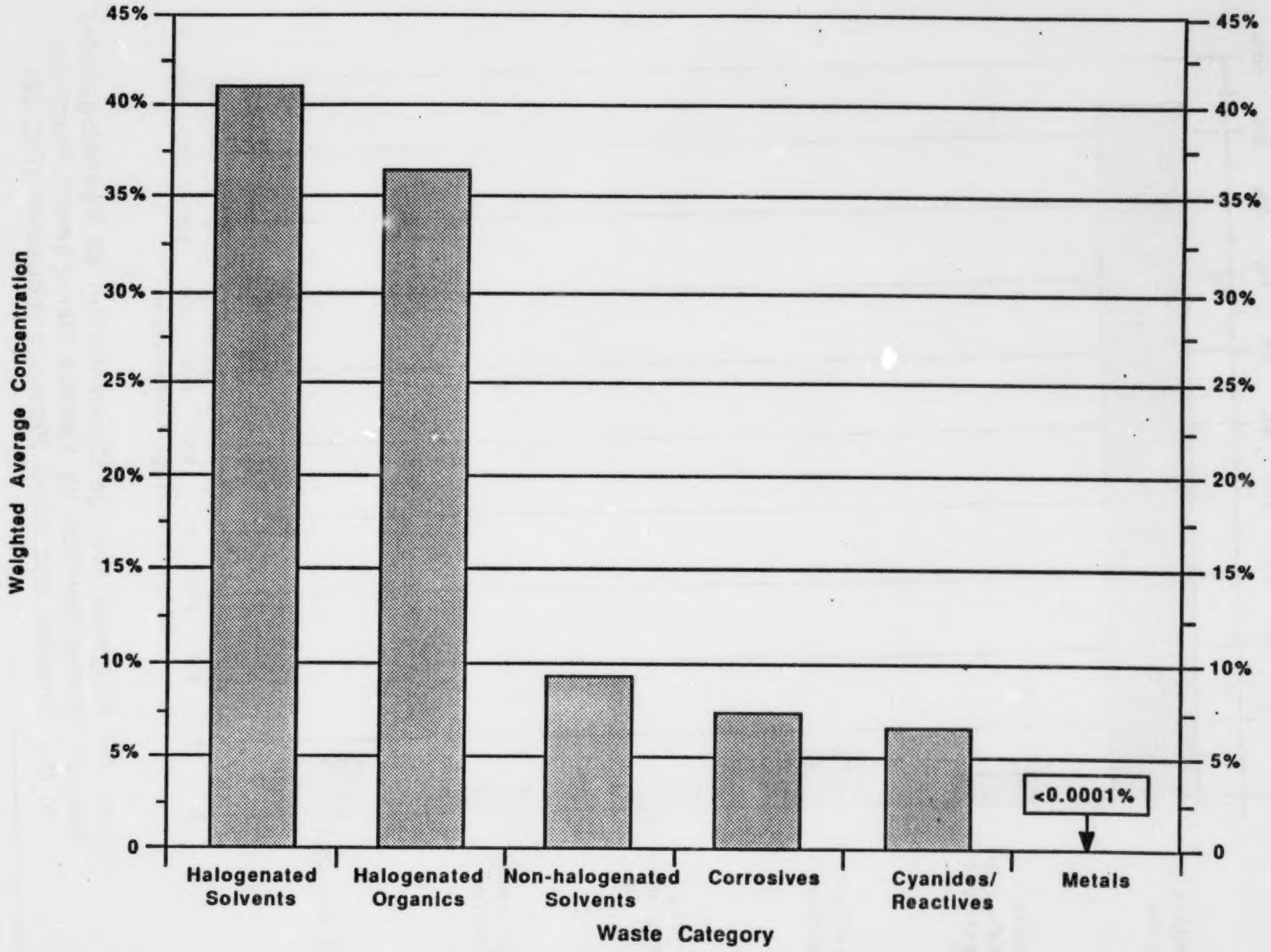


Figure 4-3 Weighted Average Concentrations of Constituents in Wastes Streams Recovered or Reused by the Chemical and Allied Products Industries (SIC 28)

Weighted Average Concentration=
Σ[(Constituent Concentration, (Weight %)) x (Constituent Waste Stream Volume)] +
Σ(Constituent Waste Stream Volume)

Source: Industrial Studies Data Base

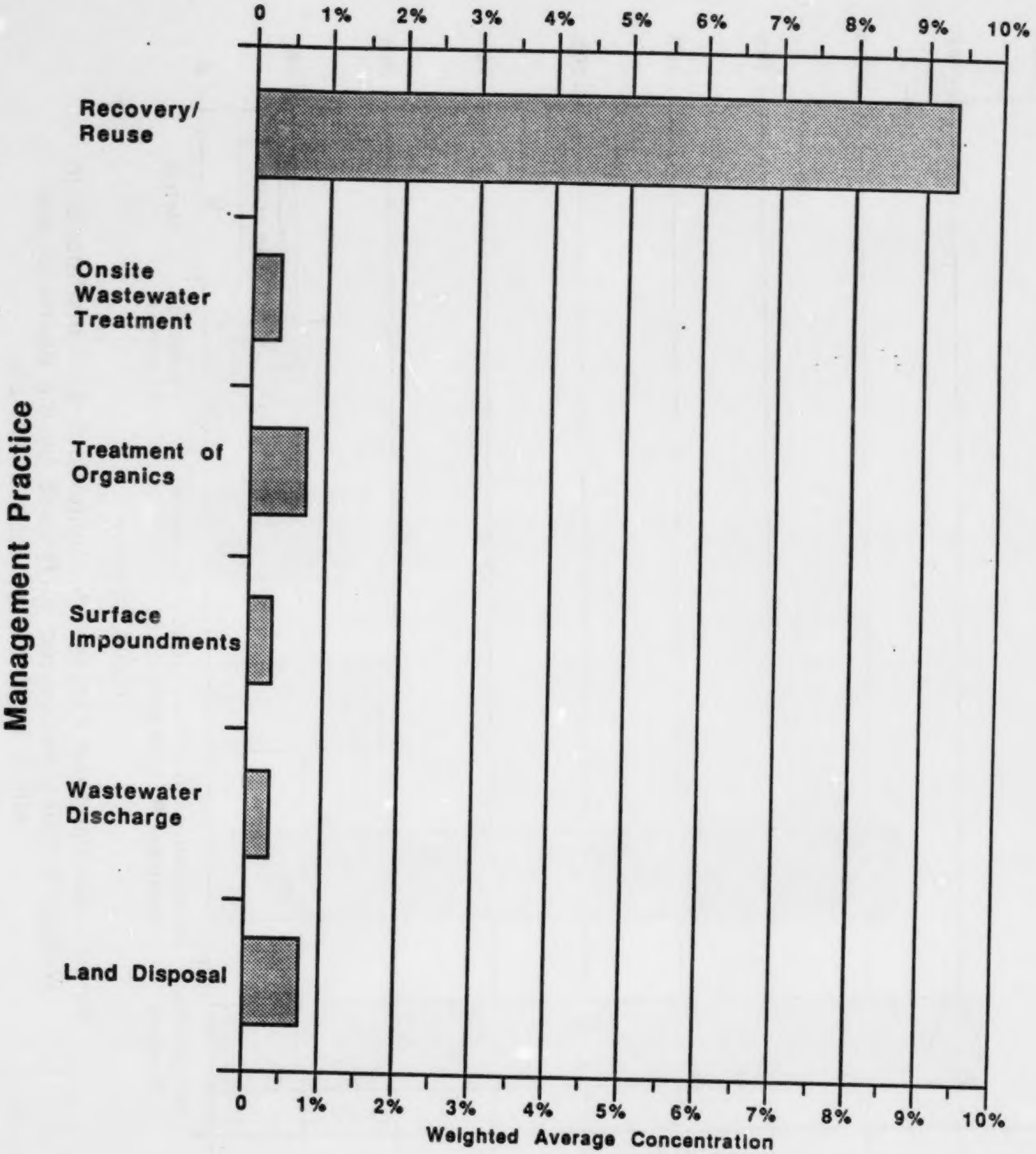


Figure 4-4 Weighted Average Concentration of Nonhalogenated Solvent Wastes Handled by Various Management Practices in the Chemical and Allied Products Industries (SIC 28)

Weighted Average Concentration=
Σ[(Constituent Concentration, (Weight %)) x
(Constituent Waste Stream Volume)] ÷
Σ(Constituent Waste Stream Volume)

Source: Industrial Studies Data Base

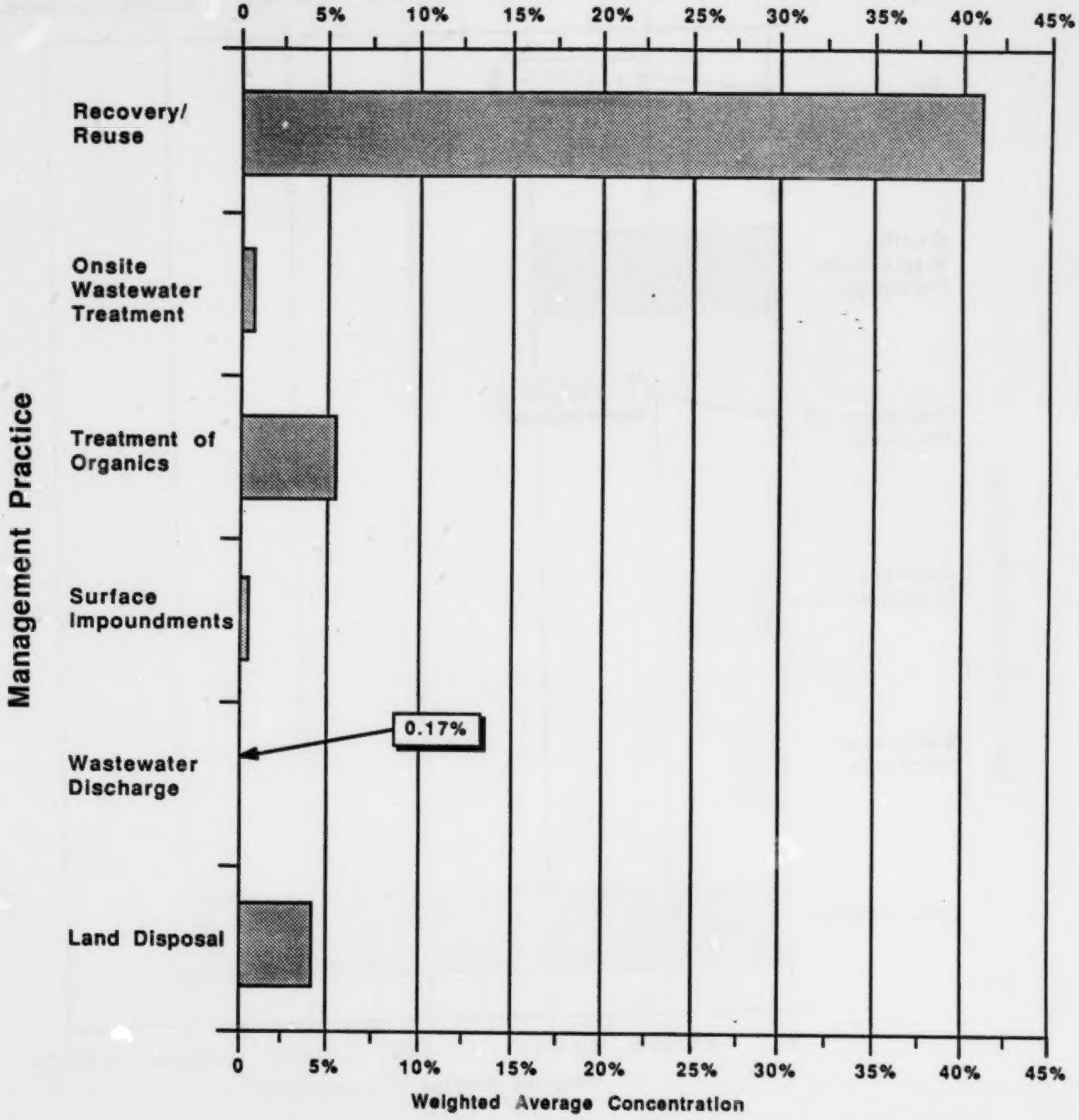


Figure 4-5 Weighted Average Concentration of Halogenated Solvent Wastes Handled by Various Management Practices in the Chemical and Allied Products Industries (SIC 28)

Weighted Average Concentration=
Σ[(Constituent Concentration, (Weight %)) x (Constituent Waste Stream Volume)] ÷
Σ(Constituent Waste Stream Volume)

Source: Industrial Studies Data Base

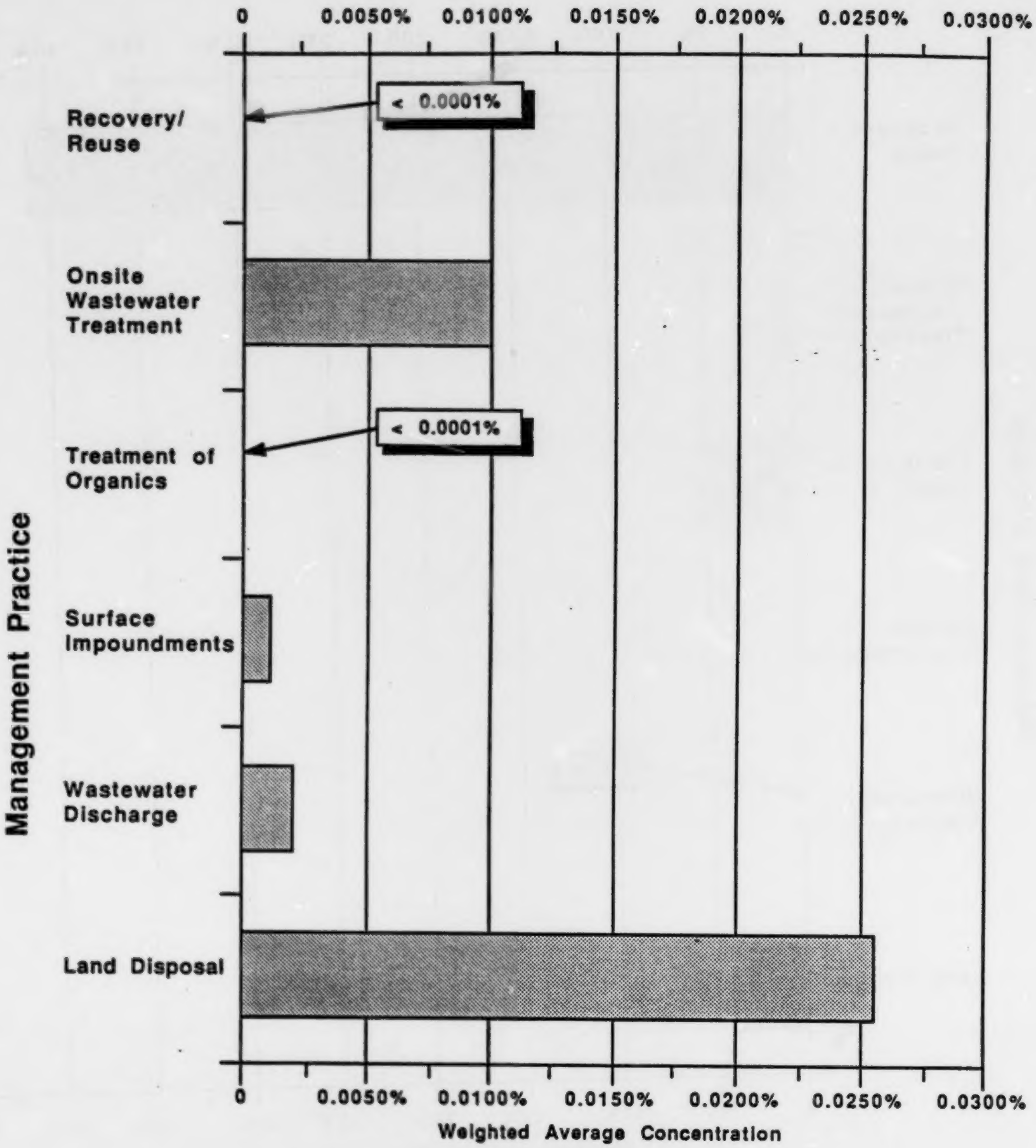


Figure 4-6 Weighted Average Concentration of Metal Wastes Handled by Various Management Practices in the Chemical and Allied Products Industries (SIC 28)

Weighted Average Concentration=
Σ[(Constituent Concentration, (Weight %)) x
(Constituent Waste Stream Volume)] ÷
Σ(Constituent Waste Stream Volume)

Source: Industrial Studies Data Base

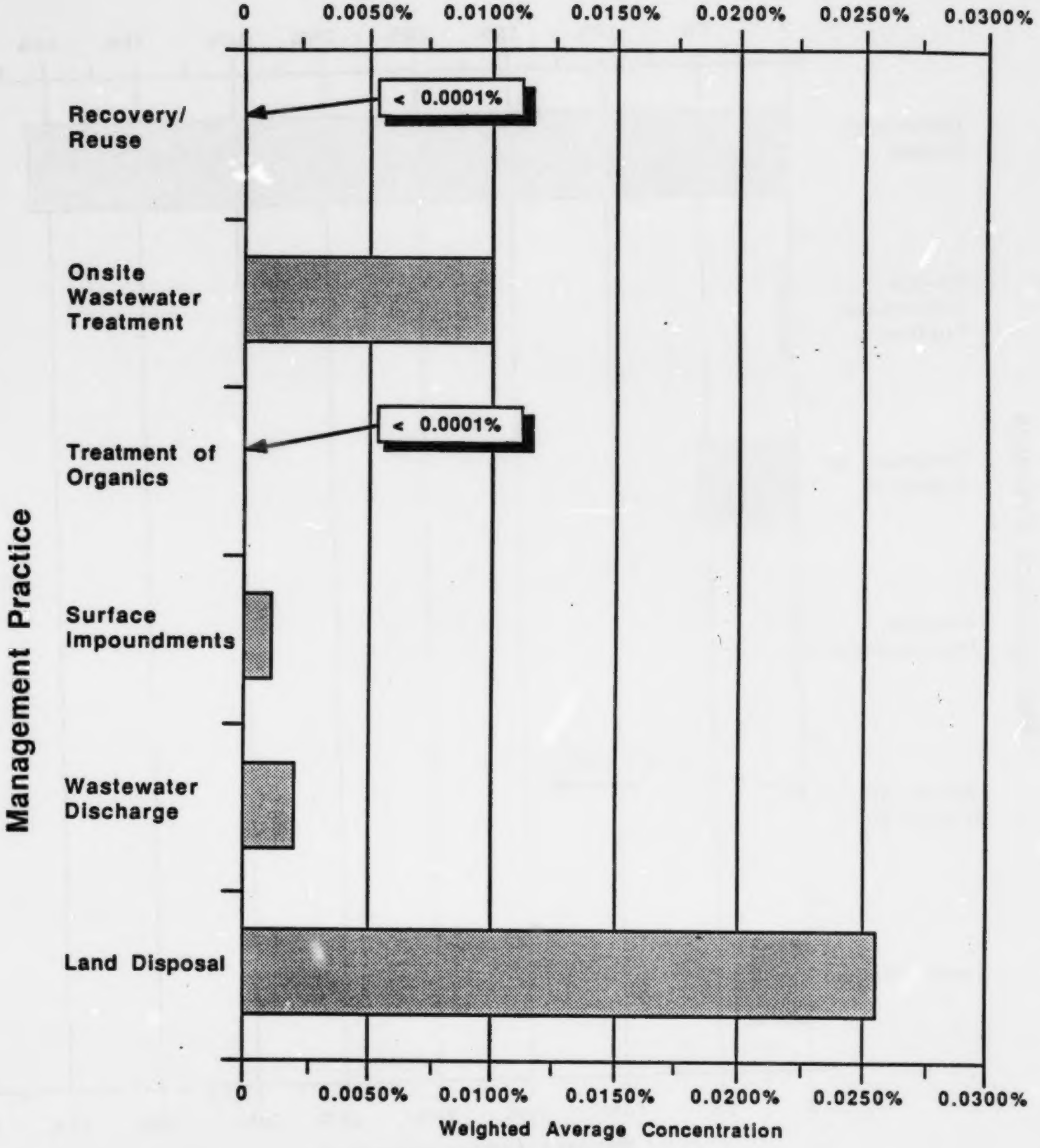


Figure 4-6 Weighted Average Concentration of Metal Wastes Handled by Various Management Practices in the Chemical and Allied Products Industries (SIC 28)

Weighted Average Concentration= Σ[(Constituent Concentration, (Weight %)) x (Constituent Waste Stream Volume)] ÷ Σ(Constituent Waste Stream Volume)

Source: Industrial Studies Data Base

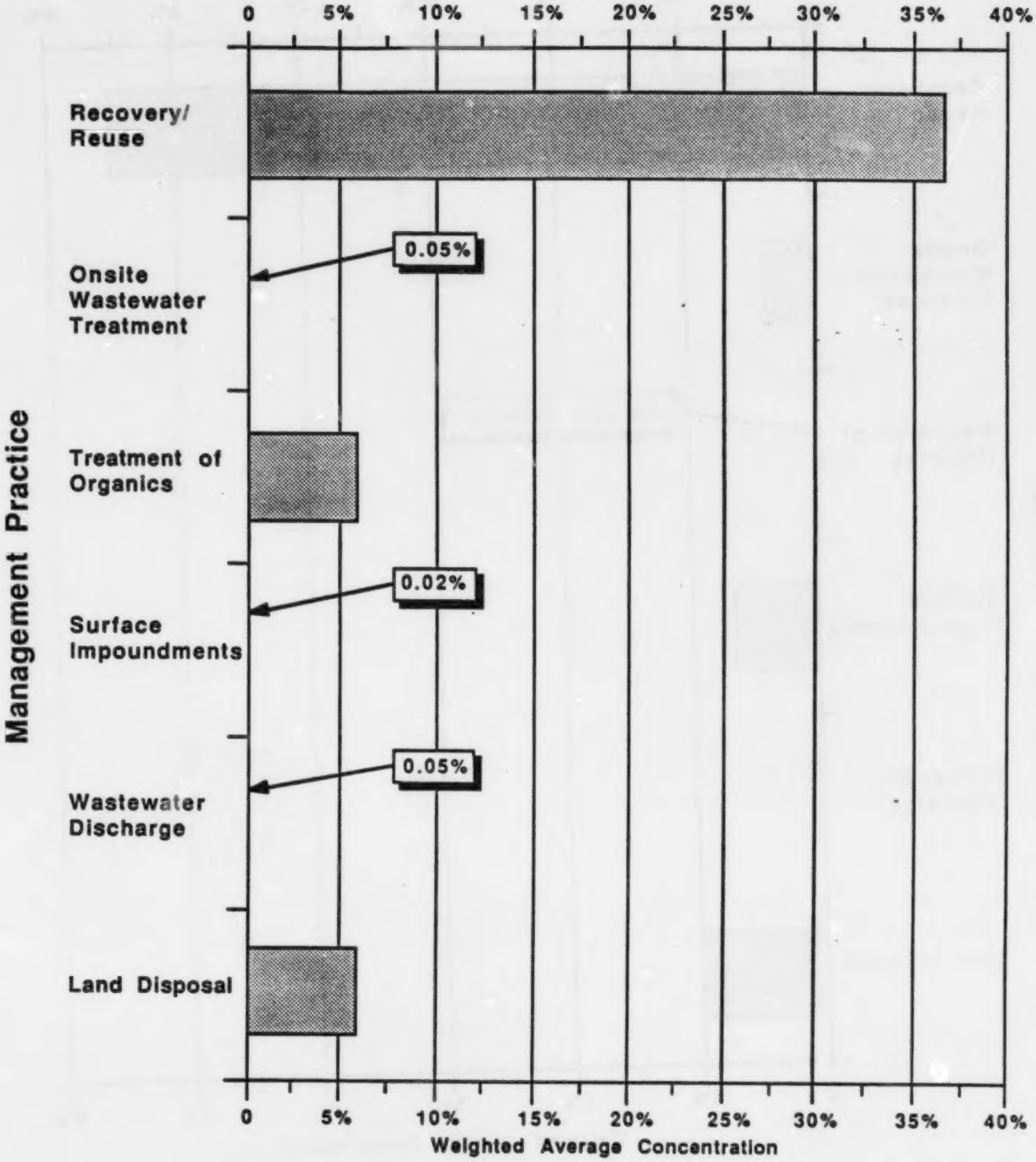


Figure 4-7 Weighted Average Concentration of Halogenated (Non-Solvent) Organic Wastes for Various Management Practices in the Chemical and Allied Products Industries (SIC 28)

Weighted Average Concentration=
Σ[(Constituent Concentration, (Weight %)) x
(Constituent Waste Stream Volume)] ÷
Σ(Constituent Waste Stream Volume)

Source: Industrial Studies Data Base

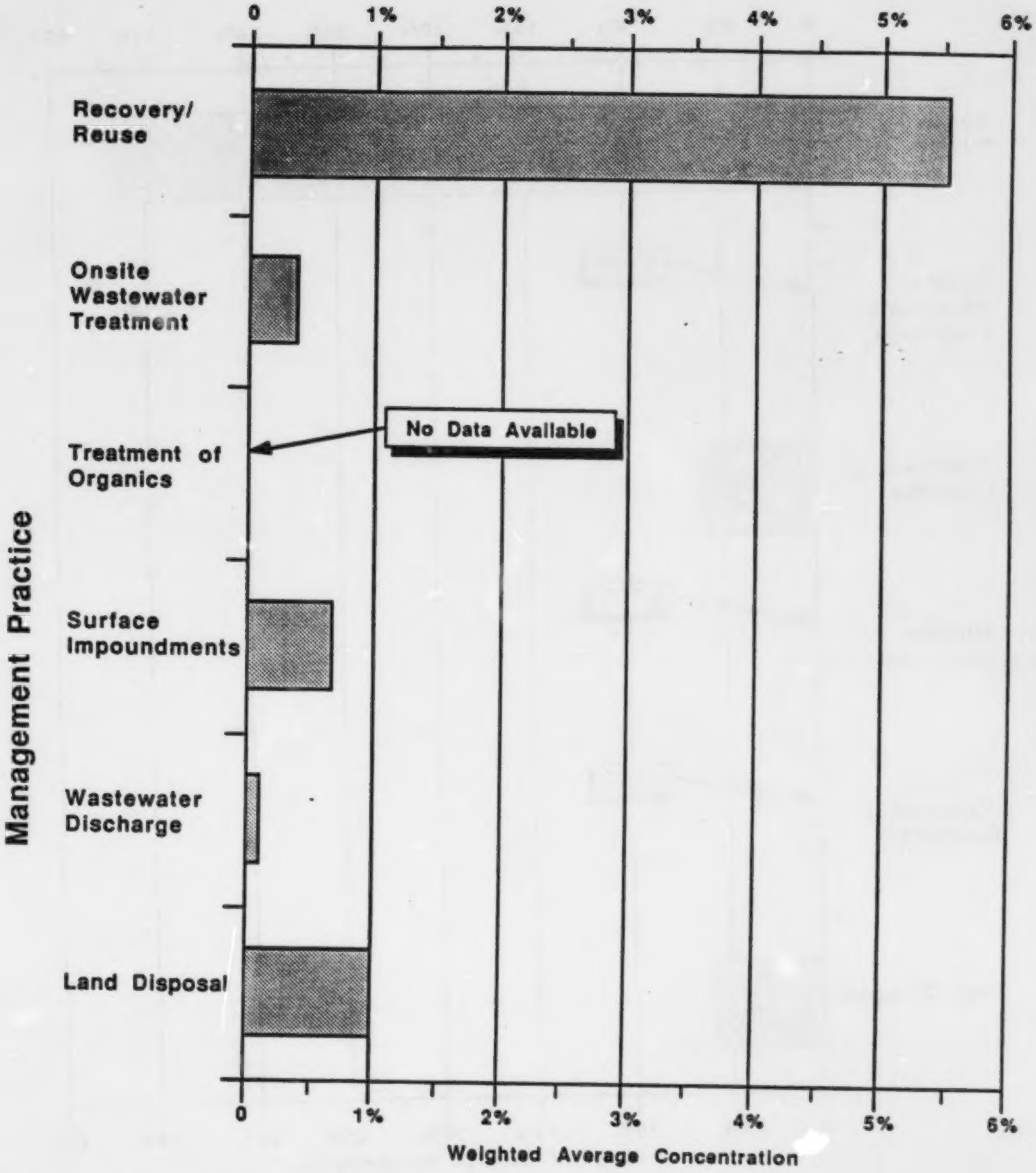


Figure 4-8 Weighted Average Concentration of Corrosive Wastes Handled by Various Management Practices in the Chemical and Allied Products Industries (SIC 28)

Weighted Average Concentration=
Σ[(Constituent Concentration, (Weight %)) x (Constituent Waste Stream Volume)] ÷
Σ(Constituent Waste Stream Volume)

Source: Industrial Studies Data Base

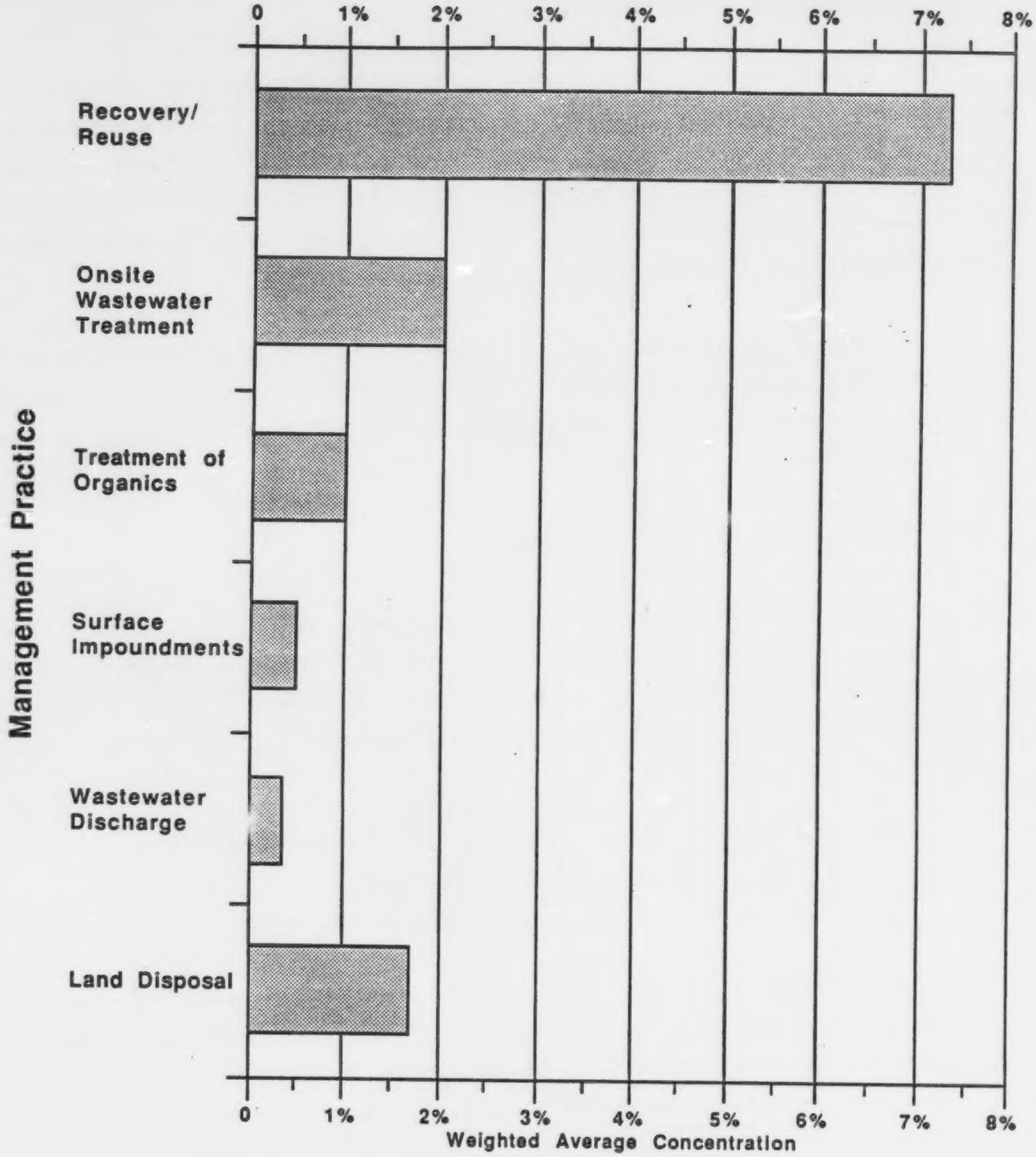


Figure 4-9 Weighted Average Concentration of Cyanide/ Reactive Wastes Handled by Various Management Practices in the Chemical and Allied Products Industries (SIC 28)

Weighted Average Concentration=
Σ[(Constituent Concentration, (Weight %)) x (Constituent Waste Stream Volume)] ÷
Σ(Constituent Waste Stream Volume)

Source: Industrial Studies Data Base

Wastes Unlikely to Be Recycled

Some production processes result in unwanted byproducts which are rarely used in any manufacturing or processing operations. For example, the residues from waste solvent distillation processes are concentrates of the same nonvolatile contaminants or impurities present in the original waste stream. These impurities generally are unwanted since there is no use for them in any production process except for heat recovery in boilers or incinerators.

Table 4-3 presents a summary of RCRA F- and K-code wastes (40 CFR 261.31) that have limited or no potential for reuse. Because of their limited potential use, source reduction may be the appropriate waste minimization strategy for these waste streams.

4.2.3 Recycling Technology Profile

Recycling technologies are easily categorized according to the type of waste treated. There are, however, some overlaps in technology applications, such as the application of centrifugation to phase separations of both inorganic and organic wastes. Categories of waste recycling technologies identified for this report include:

- Solvent waste recycling technologies;
- Halogenated organic (nonsolvent) recycling technologies;
- Metal-bearing waste recycling technologies;
- Corrosive waste recycling technologies; and
- Cyanide and reactive waste recycling technologies.

The following discussion describes applications of the more commonly used recycling technologies for each category of waste, the costs associated with different unit operations falling under each category, and the uses of the recycled products. A profile of each category of technologies is presented in Appendix C-1 through C-5.

Table 4-3 F- and K-Code Wastes Unlikely to Be Recycled in Significant Volumes

EPA waste code	Waste	Reason for limited or no recycling
F007, F008, and F009	Spent cyanide plating solutions	CN content is usually destroyed before recycle is attempted.
F010, F011, and F012	Spent cyanides containing metal treating solutions	No metals of value to recover.
F020, F021, F022, F023, F026, F027, and F028	Polychlorinated aromatic wastes	Likely to contain dioxins.
K002 - K005	Treatment sludges from chrome pigments production	Contain both trivalent chromium hydroxide and varying amounts of heavy metal chromate salts which are not easily reducible or separable.
K007	Sludges from iron blue production	These contain iron blue (iron ferrocyanide) in addition to other insoluble iron compounds. The ferrocyanide is not easily destructible.
K011	Bottoms from acrylonitrile production	Wastes are higher molecular weight cyanides: not useful in a production process. Only option for recycling is burning for fuel-value.
K013	Bottoms from acetonitrile	Same as above.
K014	Purification wastes from acetonitrile	Same as above.
K015	Still bottoms from benzyl chloride	Contains polyhalogenated aromatics of little value.

Table 4-3 (continued)

EPA waste code	Waste	Reason for limited or no recycling
K016 to K020	Still bottoms from chlorinated aliphatics	Contains higher molecular weight polyhalogenated materials of little value.
K022	Tars from phenol production	Except for its fuel value, of no value as a feedstock.
K024	Tars from phthalic acid production	Same as above.
K027	Residues from toluene diisocyanate production	Polymeric isocyanates useful only for fuel.
K095-96 and K030	Still bottoms from 1,1,1-trichloroethane	Contains higher molecular weight polyhalogenated materials of little value.
K105	Aqueous wastes from chlorobenzene production	May contain low levels of dioxins.
K073	Chlorinated hydrocarbons from chlorine products	Contains polyhalogenated materials of little value.
K031	Wastes from arseno-pesticides	Contains unwanted organoarsenates.
K032, K033, K034, & K097	Wastes from chlorinated pesticides	Contains polyhalogenated materials of little value; may also contain dioxins.
K041, K098, K042, K043,and K099	Wastes from chlorinated pesticides	Likely to be contaminated with dioxins.
K044 to K046	Explosives wastes	Safety considerations limit reuse.
K084, K101, and K102	Pharmaceutical wastes	Unwanted arsenic-containing byproducts limit reuse.

Source: U.S. Environmental Protection Agency 1980 RCRA Background Listing Document.

Solvent Recycling

Solvent recycling is achieved primarily by distillation of pure solvent from spent solvent wastes (e.g., those generated during degreasing or other equipment cleaning operations). Other types of unit operations used to recover solvents from emulsions, dispersions, or other complex solvent wastes include: solids removal, liquid-liquid separation techniques, emulsion/dispersion breaking, dissolved and emulsified organics recovery, and organic vapor recovery. Further information on solvent recycling technologies is presented in Appendix C-1.

Technical criteria for selection of technologies for the recycling of solvent wastes include the phase and concentration of the solvent, types and concentrations of contaminants in the solvent, and recycled product purity requirements. Segregation of waste streams is an important first step in solvent waste recovery. Whenever solvent wastes (or other organic wastes) are recycled for process applications, purity requirements dictate that the individual constituents be segregated to the maximum extent possible, at every step of use in the generator's facility until recovered at the reclaimer's facility. The importance of waste stream segregation is illustrated by the following examples:

- Mixed solvents with close boiling points (e.g., a solvent mixture of 1,1,1-trichloroethane (TCA) and 1,1,1-trichloroethylene (TCE)) cannot be reclaimed by pot distillation. Although recovered TCA or recovered TCE may be sold for over $2.00 per gallon, a recovered mixture of these solvents is worthless.
- If solvent wastes are to be used for fuel, care must be taken to avoid contamination with certain constituents such as inorganic chlorides, PCBs, or other highly chlorinated organics that could render the solvent unusable. For mixed solvent wastes, parallel separation and recovery operations may be required to maximize the value of the recovered constituents.

The general ranking of capital and operating/maintenance costs for solvent recovery technologies is shown in Table 4-4 and discussed below.

Table 4-4 Ranges of Costs for Technologies Used for Recovery and Recycling of Solvents

Technology	Capital costs[a]			Operating and maintenance costs[b]		
	Low	Medium	High	Low	Medium	High
Solids removal						
Gravity sedimentation	●			●		
Filtration	●	●		●	●	
Centrifugation		●	●			●
Liquid-liquid phase separation						
Decant tank	●			●		
API separator	●			●		
Tilted-plate separator		●		●		
Emulsion/dispersion breaking						
Coalescer	●			●		
Centrifuge		●	●			●
Chemical de-emulsifying agents	●			●	●	
Air flotation equipment (dissolved or diffused)		●			●	●
Dissolved & emulsified organics recovery						
Steam or air stripping		●			●	
Carbon adsorption		●			●	
Solvent extraction		●				●
Supercritical fluid extraction			●		●	
Membrane separation (ultrafiltration, reverse osmosis)		●	●		●	

Table 4-4 (continued)

Technology	Capital costs[a]			Operating and maintenance costs[b]		
	Low	Medium	High	Low	Medium	High
Organic vapor recovery						
Condensation (cooling water, chilled water, refrigeration)	●	●				
Carbon adsorption	●					
Distillation						
Pot distillation	●	●			●	
Steam distillation	●	●			●	
Fractional distillation			●			●
Film evaporation (wiped, scraped)		●			●	
Dryer (double-drum or other)			●		●	

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[a] Total installed cost ranges for commercial-sized units are broadly classified as follows: Low - under $25,000; Medium - $25,000 to $250,000; High - over $250,000.

[b] Operating and maintenance costs - direct costs for chemicals, utilities (steam, cooling water, electricity) and/or direct labor are broadly classified as follows: Low - passive, no specific requirements, direct costs under $0.02/gal; Medium - requires varying operating and maintenance labor and/or moderate chemicals or utilities, direct costs approximately $0.02 - $0.40/gal; High - requires skilled operators, lab support, frequent maintenance, and/or high chemical or utility costs, direct costs approximately $0.40/gal or over.

Distillation is a widely used technology for solvent recovery. Commercial recycling operations often use some type of distillation for solvent reclamation. Applications of some distillation unit operations are explained below. Each of the operations also is discussed in detail in Appendix C-1.

- Pot distillation is used to reclaim halogenated as well as nonhalogenated solvents from wastes. For example, acetone used as a paint cleaner commonly is recovered from nonvolatile oils, resins, and pigments, by pot distillation.

  The offsite charge for pot distillation is typically $0.50 to $1.00 per gallon, and disposal costs for pot bottoms may be additional, particularly if the waste stream has a low yield of recyclable organics. The recovered product is sold by commercial recyclers for 50 to 80 percent of virgin solvent prices with purity 95 percent or higher (personal communication with Mr. Donald L. Corey, Chemical Waste Management, Inc., Somersville, Mass., August 9, 1985). Lower purity solvents and some solvent blends may be usable in limited applications at reduced prices.

- Steam distillation is applicable to the reclamation of solvents that are water insoluble. For such wastes, steam injection allows the distillation to be performed at lower temperatures than in pot distillation.

- There is a very limited market for reclaiming both halogenated and nonhalogenated solvent mixtures using fractional distillation. The capital cost and the operating costs (energy requirement per gallon of recovered product) are much higher than with pot distillation, and tend to restrict this option only to high-priced specialty solvents and to applications in which high purity is required. Much of this recovery by fractional distillation is conducted on a toll basis for large volume generators of such waste.

Super critical fluid extraction (see Appendix C.1) is a developmental technology with no commercial applications identified during this study. However, substantial energy savings over pot distillation and fractional distillation processes are claimed for supercritical fluid extraction, with resulting operating costs as low as $0.10 per gallon (personal communication with Donald Corey, Chemical Waste Management, Inc., Sommerville, Mass., August 9, 1985).

Membrane separation of waste solvent contaminants (by ultrafiltration and reverse osmosis) has been available commercially for over 10 years, and its use has increased steadily with improvements to the process. Ultrafiltration is a membrane separation technique used by both onsite and offsite recovery facilities to separate large organic molecules (contaminants) from low molecular weight solvents. One onsite facility is replacing an air flotation unit with an ultrafiltration system. This substitution is expected to lower both operating and maintenance costs. Total operating costs for an older ultrafiltration installation at the same facility are under $0.05 per gallon (personal communication with Donald Corey, Chemical Waste Management, Inc., Sommerville, Mass., August 9, 1985).

Condensation is the recovery of solvent vapors in a cooling system. Condensation can be used alone (e.g., to recover volatile solvents from storage tanks) or in conjunction with such unit operations as distillation, carbon adsorption, and air or steam stripping.

Heat Recovery During Combustion. Solvent wastes that are highly contaminated, contain mixtures that are difficult to fractionate, or are the residues from reclamation operations, commonly are blended and reused for their fuel value. The physical properties of waste solvent blends reused for fuel are different from those of conventional fuel oils. In particular, they tend to be less viscous and to have lower flash points.

Combustion units that can accept waste solvent blends include industrial boilers, blast furnaces, light-weight aggregate kilns, cement kilns, and hazardous waste incinerators. The use of halogenated solvent wastes or waste blends in incinerators is limited to corrosion-resistant combustion systems because of the acid gas (e.g., HCl) produced during combustion. When halogenated solvent wastes are incinerated, the vent gases must be scrubbed to minimize acidic emissions.

- Industrial boilers. Combustion of solvent wastes at destruction efficiencies of 99.99 percent (required) or higher can be performed in large industrial boilers (25 million Btu/h and over), but is subject to RCRA and other environmental regulations. Boilers that fire intermittently must be modified to provide purge cycles before and after firing low-flash fuel to avoid accidental pre- or post-ignition. Currently, there are some permitted large industrial boilers combusting solvent wastes. Depending on the quality of the recycled solvent fuel, the unit value of solvent fuels combusted in industrial boilers varies from a nominal charge or credit up to $0.05 per pound for high-quality recycled fuel.

- Blast furnaces. Reuse of nonhalogenated solvents as fuel or feedstock in blast furnaces represents a substantial recycling market, particularly on a regional basis in the Midwest. A patented process, CHEM FUEL® (U.S. Patent No. 4,443.251; Cadence Chemicals), uses a wide range of pigments, resins, or solvent discards, including still bottoms, as feedstock or to supplement coke in blast furnaces.

- Light-weight aggregate kilns. Nonhalogenated solvent wastes also are used as fuel in kilns for manufacturing light-weight aggregate (expanded shale) used in building construction. Depending on the fuel quality, the kiln operator charges suppliers as low as $0.03 per pound, or gives them credit as high as $0.01 per pound, excluding taxes and the cost of transportation.

- Cement kilns and hazardous waste incinerators. Cement kilns and hazardous waste incinerators can reuse solvent waste as a supplementary fuel. Cement kilns can handle moderate levels of halogens (up to 10%), while hazardous waste incinerators can handle higher halogen levels. Unlike industrial boilers, kiln and incineration burners fire continuously and therefore can handle solvent fuels with only minor modifications.

- Other waste solvent fuel uses. Various treatment processes have been developed to blend and react solvents with fuel oil and other additives to produce a synthetic fuel with properties comparable to conventional fuel oil; solvents also are briquetted with sawdust or other organic matter for use as a coal or coke substitute. High treatment processing costs are offset by the savings in equipment modifications that would be required if treatment processing were not used.

Solvent wastes that are recycled may be reused as solvents, used in the manufacture of other products, or used as a fuel to generate heat. The following are some cases that illustrate the potential for onsite or offsite reuse of treated solvents by individual facilities:

- Charleston NSY, Charleston, S.C., has constructed a "flushing rig" out of spare parts to remove impurities from refrigerant so it can be recirculated through the system (Higgins 1985);

- Solvent vapors are recovered by Rexham Corp., Matthews, N.C., and sold to the coating industry for reuse (Kohl, Moses, and Triplett 1984);

- Southern Coatings, Sumter, S.C., operates a continuous collection system for spent solvent that is distilled; the reclaimed solvent is used primarily for cleanup (Kohl, Moses, and Triplett 1984);

- Bowling Co., Mt. Olive, N.C., distills spent acetone for reuse as a thinner (Kohl, Moses, and Triplett 1984); and

- Low-grade paint is manufactured using still bottoms from the recycling of spent solvents. Chemical Recovery Systems, Romulus, Michigan (Campbell and Glenn 1982).

Halogenated Organic (Nonsolvent) Waste Recycling

Although nonsolvent halogenated organic wastes account for only a small fraction of recycled wastes (<0.1 percent in 1981), some waste streams that are recycled include process-generated dusts and off-specification products from pesticide manufacture and formulation; still bottom residues and sludges from the manufacture of chlorinated organic compounds, degreasing operations, or solvent waste reclamation; a variety of liquid waste streams from aqueous washing steps and extractions during product manufacture; PCB-contaminated dielectric fluids; and spent solutions from treatment of wood with halogenated preservatives.

In chemical manufacturing and formulation facilities (SIC 28), recycling of wastewater contaminated with halogenated organics eliminates the expense of transporting large volumes of contaminated water to treatment or disposal sites. Feedstock recovery processes incorporated into organic chemical manufacturing processes maximize efficiency and avoid disposal of valuable materials.

A variety of unit operations are employed to recycle feedstocks and spent dielectric fluids, recover secondary products, or obtain heating energy from halogenated organic wastes. Some examples include the following:

- Pesticide dusts and rinsewaters are typically recycled onsite, where recovered materials are returned to the manufacturing or formulation process.
- Highly chlorinated still bottoms from distillation of crude halogenated solvents may be chlorinated to produce commercial grade carbon tetrachloride (Versar 1975, Versar 1980, personal communication with Mr. John Huguet, Ethyl Corporation, February 1980).
- Liquids, sludges, and other halogenated organic residues that cannot be reclaimed can be used as fuel in cement kilns, provided the waste fuel does not exceed 10 percent of the total fuel content (Stoddard et al. 1981).

- PCB-contaminated dielectric fluids are reclaimed by state-of-the-art processes that remove the PCBs by solvent extraction with dimethylformamide or dechlorination with sodium compounds.

- Hydrochloric acid is recovered as a byproduct of incineration of chlorinated organic waste. The acid is recovered by scrubbing the combustion gases with water. One use of the recovered acid is for (onsite) neutralization of alkaline waste streams. Alternatively, the acid may be concentrated and then sold for reuse.

Fees for offsite dechlorination of PCB-contaminated oils range from $1.80 to $2.50 per gallon of waste oil. The dechlorination process equipment may be mounted on mobile equipment, which can be moved by a vendor (or generator) from site to site. Availability of commercial dechlorination facilities is discussed in Section 4.3. Dechlorination is effective on wastes contaminated with PCBs at concentrations between 50 to 10,000 ppm. At concentrations greater than 10,000 ppm (1 percent), the cost of sodium reagent compares unfavorably with the cost of incineration. The charge for incineration of organic wastes currently ranges from approximately $500 per metric ton for liquid injection incineration to approximately $1,200 per metric ton for rotary kiln incineration (Pope Reid 1986). Higher rates are charged for halogenated organic wastes (Pope Reid 1986).

Recycling and disposal costs for other nonsolvent halogenated organic wastes are dependent primarily on the heating value and chlorine content of the waste. Premiums may be charged for high concentrations of specific contaminants (e.g., ash, solids, or PCBs). The price of fuel with a good heating value (over 100,000 Btu per gallon) and 2 to 3 percent chlorine varies from $20 per ton credit to $20 per ton charge delivered (taxes and transportation not included); the charge is higher for wastes with a lower heating value, higher chlorine content, and other contaminants (personal communication with Donald Corey, Chemical Waste Management, Inc., Sommerville, Mass., August 9, 1985). The maximum halogen loading for wastes to be used as fuel is usually 5 to 10 percent. (Further information on halogenated organics is presented in Appendix C-2.)

Recycling of Metal-Bearing Wastes

Toxic metal-bearing wastes are hazardous wastes containing significant levels of metals, and organic and inorganic metal compounds. Examples of metal wastes are alkali metals, mercury-bearing sludges from chloralkali production, chromate- and iron cyanide-based pigments, and ferrous chloride-based pickle liquor. Iron cyanide-based pigments also fall under the category of cyanide/reactive wastes, although they are not an EP Toxic-category waste. The pickle liquor is a reactive waste as well as a metal waste. Technologies used for recovery and recycling of metal-bearing waste streams include:

- Metal concentration processes;
- Metal reduction and recovery;
- Particulate and vapor recovery;
- Cyanide destruction; and
- Agglomeration techniques (not widely used).

These technologies will be discussed in detail because recycling of metal-bearing waste streams accounts for a large volume of the total waste recycled by U.S. industries.

Metal Concentration Techniques

Metal concentration techniques have wide application in both onsite and offsite recycling operations (e.g., recovery of metals from plating and finishing solutions). Metal concentration techniques include hydrometallurgical processing (leaching), solvent extraction, ion exchange, precipitation, crystallization, calcination, evaporation, membrane separation, adsorption, and foam flotation. A great deal of current technological work is focused on methods to economically concentrate metal compounds into a solution or sludge from a bulk solid or liquid (personal communication with Donald Corey, Chemical Waste Management, Inc., Sommerville, Mass., August 9, 1985). The range of capital costs and operating/maintenance costs for metal recycling techniques is presented in Table 4-5. The variety of metal-bearing waste streams makes generalization difficult. As with other waste categories, segregation of metals during processing and reclamation simplifies and improves the economics of metals recovery.

Table 4-5 Ranges of Costs for Technologies Used for Recovery and Recycling of Metals

Technology	Capital costs[a]			Operating and maintenance costs[b]		
	Low	Medium	High	Low	Medium	High
Metal concentration processes						
Hydrometallurgical (leaching)		●			●	●
Solvent extraction		●			●	●
Ion exchange	●			●	●	
Precipitation		●		●	●	
Crystallization	●	●			●	
Calcination			●		●	
Evaporation	●	●			●	
Membrane separation (reverse osmosis, electrodialysis)		●			●	●
Adsorption	●			●		
Foam flotation	●	●			●	
Metal reduction and recovery						
Electrolytic recovery		●			●	
Sodium borohydride	●				●	●
Reduction furnaces			●			
Other reducing processes	●			●		
Particulate and vapor recovery						
Particulate recovery	●	●			●	
Selective adsorbents	●	●			●	
Wet scrubbers		●	●		●	●

Table 4-5 (continued)

Technology	Capital costs[a]			Operating and maintenance costs[b]		
	Low	Medium	High	Low	Medium	High
Cyanide destruction		●			●	
Agglomeration - feed to furnaces						
Pelletizing		●			●	
Green balling	●			●		

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[a] Total installed cost ranges for commercial-sized units are broadly classified as follows: Low - under $25,000; Medium - $25,000 to $250,000; High - over $250,000.

[b] Direct costs for chemicals, utilities (steam, cooling water, electricity), and/or direct labor are broadly classified as follows: Low - passive, no specific requirements, direct costs under $0.02/gal; Medium - requires varying operating and maintenance labor and/or moderate chemicals or utilities, direct costs approximately $0.02 - $0.40/gal; High - requires skilled operators, lab support, frequent maintenance, and/or high chemical or utility costs, direct costs approximately $0.40/gal or over.

- Hydrometallurgical concentration (leaching). Most metals can be leached out of solids and sludges by extended contact with specific acids. Leaching of metals with sulfuric acid, although inexpensive (approximately $70 per ton), causes minor corrosion problems and is not selective. Ammonia and ammonium carbonate are leaching solutions having the best selectivity for solubilizing copper and nickel, but are more expensive than sulfuric acid (Mehta 1981).

- Solvent extraction. Selective solvents can be used to extract and concentrate metal cations from leachates and other metal-bearing solutions. The cost of such operations limits commercial applications.

- Ion exchange resins. Ion exchange resins are used extensively in large plating shops to reconstitute rinsing waters. Two liquid ion exchange resins that are commercially available are dinonyl-naphthalene sulfonic acid and didodecylnapthalene sulfonic acid (Peterson et al. 1982). A limitation in the commercial application of ion exchange resins as a metals concentration process is the uncertain life of the resins compared with their fairly high cost. Loss of resin efficiency resulting from plugging and fouling is minimized, however, by prefiltering the waste feed. Cyanide baths and cyanide rinse waters can poison the resin and can result in loss of metals that come out of solution as complexes instead of simple cations.

- Precipitation. A commonly reported wastewater treatment method for toxic metals is hydroxide precipitation using either lime or caustic soda (Peterson et al. 1982). It is, however, often difficult to recover metals from the hydroxide sludges. In some cases sulfide precipitation is used following a reduction step such as ferrous reduction of hexavalent to trivalent chromium (Higgins and TerMaath 1982). Metal ferrites can be precipitated from wastewater by the addition of a ferrous salt. The metal ferrites are recoverable because of the size of the crystals and their magnetic properties.

- Crystallization. Ferrous sulfate is recovered from pickling acid by cooling the solution to lower the solubility of the metal salts. In a similar process, copper sulfate is removed from copper etching baths by refrigerating or freezing the bath. The latter process is used by a number of printed circuit fabricators and metal finishing shops (personal communication with Gerd Scharlack, Keramchemie, Don Mills, Ontario, Canada, 1986).

- Calcination. Lead oxide is recovered from leaded tank bottoms by reacting the sludge at high temperature to drive off water and other volatiles, incinerating residual organics, and oxidizing the lead.

- Evaporation. Chromium is recovered from chromium rinse tanks by evaporation, often in combination with ion exchange. The major limitation of evaporation for concentrating metals solutions is the high energy requirement for heating, although solar evaporation may be used in the West. In order for evaporation to be cost-effective, the waste solutions must be high in metals, a condition achieved in the electroplating industry by process modifications such as countercurrent rinsing. In addition, the use of multiple-effect evaporators instead of single-effect evaporators reduces energy consumption.

- Membrane Separation. Substantial improvements in membrane technology have resulted in increased commercial use of some membrane separation technologies (ultrafiltration, reverse osmosis) for metal recovery in recent years. Some examples of applications of membrane separation technology include the following:
  - Ultrafiltration membranes are used to pretreat organic solutions by removing suspended, colloidal, and large molecular dissolved solids.
  - Reverse osmosis has been used widely for such commercial applications as the recovery of nickel from nickel-plating solutions. In addition, reverse osmosis has been used to recover metals from mixed plating wastes, copper- and zinc-plating solutions, and silver-bearing photoprocessing solutions (Daignault 1977). A limitation of the reverse osmosis process is associated with the membrane's strength to withstand extreme temperature and pH conditions. For example, chromic acid and high pH cyanide baths have been particularly difficult to treat by reverse osmosis. However, Rozelle et al. (1973) reported development of a polymer membrane for reverse osmosis treatment of both acidic and alkaline finishing solutions.
- Electrodialysis. This process involves the application of an electrical potential across a membrane and appears to be limited in its commercial application for technical and economic reasons.
- Adsorption. Columns of natural or synthetic adsorbents can be used to selectively remove metals from wastewaters. The metals are then recovered by regenerating the column with acid.
- Foam Flotation. This is a relatively new process, demonstrated to effectively remove copper, zinc, chromium, or lead from solution. The process involves the flotation of foams after addition of polyelectrolyte and adjusting the pH. No commercial installations of foam flotation equipment were identified during this report.

Many of the other unit operations used for metals recovery are widely used and continuously improved. Christensen and Delwiche (1982) reported effective removal of chromium, nickel, copper, and zinc from electroplating rinse waters by a three-step system of hydroxide precipitation, flocculation, and ultrafiltration. Various improvements in metals reduction by electrolytic recovery have been made to enhance mass transfer rates, extend electrode life, and remove continuously deposited metals from flat electrode plates. Although in most instances it is best to use the electrolytic recovery process on segregated metal waste streams, Battelle

(Columbus, Ohio) and Rolla Metallurgy Center have developed an electrolytic process that removes copper from a mixed-metals leachate. Silver can be electrolytically recovered from spent photographic developing solutions (Daignault 1977).

The principal use of metals recovered from hazardous wastes is for onsite recycling as a feedstock. Examples of recycled feedstocks include mill scale recycled to steel mills, lead oxide recycled to tetraethyl lead manufacture, and reclamation of process baths and rinse tanks in metal finishing industries. Onsite recycling of these feedstocks can be cost-effective in major facilities.

Offsite metal recycling activities include both the recovery of scrap metals for re-refining, and recovery of metal compounds for other applications. Commercial recyclers charge or credit the generator for metal-bearing wastes depending on the specific metal that is recovered and its concentration. The highest credit per pound for a recovered metal is approximately 50 percent of the current market price for that metal. For a dilute solution, the charge (excluding transportation and taxes) is approximately the same as for disposal. Some examples of metal-bearing wastes recycled offsite and uses of the recovered products are:

- Recovery of zinc contained in flue dust from steel mills. The zinc is used for production of zinc and technical grade zinc salts;
- Recovery of vanadium from spent sulfuric acid catalysts;
- Reuse of metal solutions and sludges (e.g., copper, nickel, and zinc) as raw materials in chemical manufacture;
- Recovery of trace metals (copper, boron, manganese, zinc, and magnesium) for fertilizer manufacture;
- Recovery of metal hydroxides from concentrated sludges for manufacturing metal salts;
- Recovery of precious metals; and
- Recovery of cobalt and molybdenum, along with nickel and vanadium, from hydrotreating catalysts used in petroleum refining.

Since precious metals (gold, platinum, palladium) can be recovered almost quantitatively from waste solutions, there are numerous onsite recovery operations as well as offsite re-refineries for those metals. Re-refiners also actively seek silver-bearing wastes from any of the following sources: used photographic film; photographic paper; electrolytic silver (flake); ash from burning of photographic film or paper; metallic replacement cartridges; and other solutions and sludges. (Further information on metals is presented in Appendix C-3.)

Corrosive Waste Recycling Technologies

Techniques commonly used to recycle corrosive wastes are thermal decomposition, evaporation, crystallization, ion exchange, and oxidation. Several of these technologies overlap those described above for metals because many corrosive wastes are metal-bearing solutions or sludges. Uses for spent corrosive solutions typically are found in large volume applications and in basic or heavy industrial classifications. See Appendix C-4 for further information on corrosives.

Thermal decomposition is used in the recovery of at least three types of materials: (1) spent alkylating acid from petroleum refineries; (2) acid values from spent pickle liquor; and (3) hydrochloric acid from chlorinated hydrocarbon wastes.

- Spent alkylating acids (RCRA waste code D002) from petroleum refining consist of sulfuric acid contaminated with organic materials. This spent acid is frequently returned to nearby sulfuric acid plants where it is thermally decomposed to sulfur dioxide, water, and oxygen. The sulfur dioxide is recovered and used to produce fresh acid, which is then supplied to the refineries (Versar 1980). Recovery of spent alkylating acid is widely practiced among major petroleum refineries, and spent acid processing plants are generally located adjacent to major refineries (personal communication with Gordon Jolley, Exxon Chemical Americas, Baton Rouge, La., June 13, 1985). Allied-Signal, Stauffer, duPont, and American Cyanamid all operate such facilities near major petroleum refineries located in the Northeast and along the Gulf Coast.

- Recovery of hydrochloric acid from pickle liquor (K062) could be practiced at many iron and steel mills. Though the costs of the operation are high and account, in part, for its infrequent use, recovered acid could be of significant value. Currently, iron chlorides are recovered from this waste more often than HCl.

- Halogenated acids are recovered by scrubbing of vent gases of incinerators burning highly halogenated wastes (Inform 1985). The incinerator off-gases are water scrubbed to generate dilute HCl solutions, which are concentrated for sale or internal reuse. The Dow Chemical facility in Pittsburg, California, uses this technology (Inform 1985).

Evaporation. Processes based on evaporation are another extensively used method for recovery of corrosive wastes.

- DuPont recovers ferric chloride from titanium dioxide process wastes. Partial evaporation of the process wastes generates a 40 percent ferric chloride solution that can be resold. Use of such technology has provided duPont with an additional product line and has eliminated the cost of neutralizing large volumes of aqueous ferric chloride wastes. Further application of this technology, however, is constrained by limited markets for ferric chloride, which competes with alum for use as a water treatment chemical.

- Evaporation is also applicable to corrosive acid and alkali solutions. Dilute solutions of sodium hydroxide, phosphoric acid, chromic acid, and nitric acid are corrosives suitable for concentration by evaporation. Many alumina plants reconcentrate spent dilute caustic by evaporation to regenerate 50 percent caustic solutions for internal reuse (Versar 1980). These efforts reduce the need to purchase large volumes of this raw material and to neutralize large volumes of spent dilute caustic.

- Several chloralkali producers send spent sulfuric acid, used for chlorine drying, to sulfuric acid plants for reconcentration (personal communication with Edward Laubusch, Chlorine Institute, New York, N.Y., June 18, 1985). This effort also saves the costs involved in neutralization or disposal of a corrosive waste.

- Spent nitrating acids from production of either fuming nitric acid or organic nitro compounds are also reclaimed by distillation or evaporation methods (personal communication with John Cooper, duPont, Wilmington, Del., July 1, 1985).

- Phosphoric acid is concentrated to standard acid strength by evaporation under vacuum. This is normally done in the production of wet-process phosphoric acid in the fertilizer industry. The metal plating industry may evaporate chromic acid solutions from plating-rinse tanks. This option has been proposed for use in the electroplating industry; the extent to which it is currently used is unknown.

Crystallization is another practice in use for the recycling of corrosive wastes. In metal finishing operations, iron salts (mainly ferrous sulfate) are crystallized from pickle liquor solutions, and sulfuric acid is recycled to the pickling baths. Commercial processes use cooling, either direct or indirect or combinations of the two, to trigger crystallization.

- Ferrous sulfate is recovered by crystallization in large steel mills where the capital outlay for the equipment is offset by the large volume of pickle liquor (Versar 1980). The separated ferrous sulfate is adequate for use as a flocculating agent in wastewater treatment plants. The value of recovered ferrous sulfate, disposal costs, and availability of a market for ferrous sulfate are also included in the process economics. A similar process exists for recovery of ferric chloride from spent HCl acid pickling solutions. This process shows little economic promise for the metal finishing industry, which consists of many generators of small quantities of pickle liquor. Reconcentration of original acid is energy-intensive and is practiced only by a few commercial recyclers, who procure spent pickle liquor from other local firms and convert it to ferric chloride for sale (personal communication, Howard Kaiser, Director of Environmental Affairs, Conservation Chemical, July 16, 1985).

- Cupric chloride and copper sulfate also may be recovered from copper cleaning solutions through crystallization. Printed circuit manufacturers and metal finishers make use of this because the value of the copper salts justifies use of the process.

- Aluminum hydroxide (hydrated alumina) is recovered from aluminum etch solution by a recently developed cooling process. The etch solution is recycled directly, whereas the alumina can be sold in bulk as a raw material to an aluminum producer.

Ion exchange resins are capable of removing heavy metals and cyanides from acid and base solutions. The process is applicable in the electroplating, metal finishing, and fertilizer manufacturing industries and has been used at numerous installations since the mid 1970s.

Oxidation is another technique for corrosive material recovery. Byproduct hydrogen chloride can be oxidized to produce chlorine. The chlorine is then used to produce chlorinated hydrocarbons. DuPont operates the process at their Corpus Christi, Texas, facility (written communication from J. Cooper, E.I. duPont de Nemours, October 1985).

Recycling Technologies for Cyanides and Reactive Wastes

This section describes techniques used for recycling cyanide and reactive wastes. Several examples are presented of recycling technologies either in current use or in development.

Cyanides. Potential techniques for recovering and recycling cyanide solutions from metal plating (e.g., zinc, cadmium, brass, and silver plating) are: (1) refrigeration/crystallization, (2) evaporation, (3) ion exchange, and (4) membrane separation (reverse osmosis or electrodialysis). A refrigeration/crystallization process for removal and recycling of cyanide from plating solutions that contain excessive amounts of sodium carbonate has been patented by the Department of Defense (DOD). Although this process is considered promising by some members of the electroplating industry, its widespread use is limited by formalities involved in obtaining necessary permission for use from the DOD.

One type of cyanide waste that is commonly recycled is cyanide wastewater from precious metal beneficiation. After traces of gold or silver are precipitated with zinc or adsorbed onto carbon, the cyanide solution can be recycled. However, in other industries, such as Transportation Equipment (SIC 37), cyanide wastewaters are treated to recover metals, and the residual cyanide is destroyed by alkaline chlorination. The relatively low cost of fresh cyanide makes this practice the most cost-efficient for management. (See Appendix C-5 for further information.)

Reactive Wastes. The major technology currently used to recycle reactives is a metal substitution process. Sodium metal is recovered from reactive sodium-calcium alloy wastes using a closed loop system which involves a replacement reaction between calcium and salt. This technology is in use at the duPont, Niagara Falls, New York, sodium production plant where 1,000 tons of usable sodium are recovered and 1,200 tons of RCRA hazardous wastes are eliminated per year (from written communication with J. Cooper, E.I. duPont de Nemours, October 1985).

The primary barrier to the recycling of other water-reactive wastes (e.g., most alkali metal wastes) is technical feasibility. There are, however, efforts underway at DOD facilities to investigate possibilities of overcoming this problem.

A technique using evaporation is being studied to reclaim ammonium perchlorate from propellant wastes. A process to recover cyclotrimethylene base trinetramine and cyclotetrametaylene tetranitroamine (RDX and HMX), which is based on solubility differences, is also being studied by the explosives industry. Elemental phosphorus is recovered from phosphorous wastes by a retorting process that is widely used in the phosphorus chemicals segment of the inorganic chemicals industry (Versar 1980). (See Appendix C-5 for further information.)

4.3 Offsite Recycling

Offsite recycling of hazardous wastes is a management option for some generators. A generator's decision to recycle offsite depends on such factors as the size of the company, the volume of the waste, and the expertise available within the plant or facility. Options for offsite recycling that are discussed in this section include commercial recycling facilities, waste exchanges, and other cooperative arrangements.

4.3.1 Commercial Recycling Facilities

Many recycling facilities are privately owned companies that accept hazardous wastes from generators, and then process the wastes to make them suitable for reuse. Profits are derived from the income the companies receive by reselling the recycled wastes as raw materials.

Depending on the type of waste, the commercial recycler may buy hazardous wastes from a generator or charge the generator a fee for accepting the waste. The value of a waste to a commercial recycler depends on the type, market value, purity (quality), and quantity, of waste generated; how often the waste is produced; and the distance between the generating facility and the recycling facility.

Both mobile and stationary treatment equipment is available. Mobile recycling/treatment units include detachable trailers of recycling (or treatment) equipment that can be moved periodically to the generator's premises, where it is operated by the commercial recycler. A number of companies with mobile PCB-oil treatment facilities have been issued PCB-disposal permits by EPA headquarters (Pesticide and Toxic Chemical News, 1985). These facilities include:

- Acurex, Mountain View, California (chemical dechlorination);
- Chemical Decontamination Corporation, Birdsboro, Pennsylvania (chemical dechlorination);
- Quadrex HPS, Gainsville, Florida (physical separation);
- Sunohio, Canton, Ohio (chemical dechlorination); and
- Transformer Consultants, Akron, Ohio (chemical dechlorination).

American Mobile Oil Purification, (New York) and Acurex have active research and development permits for mobile chemical dechlorination and physical separation systems, respectively.

Another form of commercial recycling is an arrangement called batch tolling. Through this arrangement, a commercial recycler may accept hazardous waste from a generator, treat it, and return the recovered product to the same generator, charging the generator a fee for this service. This agreement would be attractive to a generator if the cost of the reclaimed material from the batch toller were cheaper than the equivalent virgin material inclusive of transportation and handling costs. Companies generating small volumes of a waste and/or located substantial distances from a batch toller, however, could find the economics for purchasing virgin material to be preferable to that of recycling. (See also Section 5.2.3 for a discussion of the effect of liability on costs of transportation of hazardous wastes.)

A variation of this type of batch-tolling agreement is practiced by some companies who sell chemicals for use in processes and agree to buy back or accept the spent material for reclamation. For example, CP Chemicals in Sewaren, New Jersey, manufactures plating chemicals and accepts spent plating solutions from customers for reformulation. CP Chemical then supplies the reformulated solutions to the customers (personal communication with Vincent Krajewski, Director of Environmental Affairs, CP Chemical, Sewaren, N.J., July 16, 1985).

Harshaw-Filtrol has similar arrangements with its long-term customers (personal communication with Mr. David Wilson, Manager of Environmental Affairs and Safety, Harshaw-Filtrol, Cleveland, Ohio, July 16, 1985).

Safety Kleen, a commercial recycler headquartered in Elgin, Illinois, provides a similar type of batch-tolling service, but goes a step further by supplying the process equipment and chemicals as one unit. The company operates mobile units that provide fully-contained degreasing systems to user (generator) facilities in a variety of locations throughout the United States. Safety Kleen leases systems consisting of solvents contained in an apparatus used for degreasing machine parts. On a periodic basis, Safety Kleen's mobile units return to the generator's facility and replace spent solvent with fresh solvent. Then the spent solvent is transported to a central recycling facility. The generator is assured of having the waste recycled and avoids some of the paperwork and costs of transporting a hazardous waste.

Additional information on the locations and services of commercial recyclers is being compiled by the USEPA Office of Solid Waste (OSW), Waste Management Division, Waste Treatment Branch. Several data bases are used by OSW to access such information including the Hazardous Waste Data Management System (HWDMS), the RIA (1981) Mail Survey data base, and the RCRA Biennial data base. Recently, the recycling facility information contained in these sources was compared with several commercial directories, including the Hazardous Waste Services Directory (J. J. Keller 1984) and Industrial and Hazardous Waste Management Firms 1985 (Environmental Information Ltd. 1985).

4.3.2 Waste Exchanges

One alternative to onsite recycling or shipping wastes offsite to commercial recyclers is direct shipment of wastes to other companies who can use the waste material in their operations. Recipient companies either use the waste untreated or subject it to a minimal amount of treatment before reuse. The success of such waste transfer operations depends on (1) the supply and demand for a specific waste and (2) a mechanism by which interested parties can make contact and negotiate an agreement. Waste exchanges are private or government-funded organizations that facilitate recycling transactions by identifying the supply and demand for specific wastes and bringing together waste generators and potential waste users.

Wastes currently recycled through waste exchanges include acids, alkalis, other inorganic chemicals, organics and solvents, metals, and metal sludges.

- Solvents and metal wastes are frequently listed by waste exchanges because they have a high recovery value.
- Corrosives also are frequently listed, and are exchanged for use in neutralization processes. Although metal-bearing cyanide wastes are listed, usually only the metals are recovered and the cyanides are destroyed.
- Reactives, such as explosive wastes, are rarely listed by waste exchanges because of their low recovery potential and the difficulties involved with transporting them.
- Some halogenated organic wastes, in particular pesticides and PCBs, are rarely recycled and thus are not listed by waste exchanges. Approximately 20 to 30 percent of listed wastes are exchanged (i.e., either acquired or sold) (Industrial Material Exchange 1985; Banning and Hoefer 1983, Banning 1984; Piedmont Waste Exchange 1984).

There are two types of waste exchanges: Information Exchanges, which act as clearinghouses through which interested parties can find out what wastes are available and what wastes are wanted; and Material Exchanges, which take temporary physical possession of the waste and may initiate or actively participate in the actual transfer of wastes to users. (A list of information exchanges and material exchanges is provided in Table 4-6. Further information on the exchanges is provided in Appendix C-6.) Supplementing the activities of these two types of waste exchanges are waste brokers. The brokers, for a fee, locate either a generator of a wanted waste, or a company that can make use of a particular waste type.

Information Exchanges

At present, information exchanges are the most prevalent type of waste exchange. Through such services, industries can find published lists of wastes

Table 4-6 List of Information and Material Waste Exchanges

Organization/Address/Telephone	Contact person
Information Exchanges:	
California Waste Exchange Department of Health Services Toxic Substances Control Division 714 P Street Sacramento, California 95814 (916) 324-1818	Robert McCormick
Canadian Waste Materials Exchange Ontario Research Foundation Sheridan Park Research Community Mississauga, Ontario CANADA L5K 1B3 (416) 822-4111	Robert Laughlin, PhD
Chemical Recycle Information Program Houston Chamber of Commerce 1100 Milam Building, 25th Floor Houston, Texas 77002 (713) 658-2462	Jack Westney
Georgia Waste Exchange Business Council of Georgia P.O. Box 7178, Station A Marietta, Georgia 30065 (404) 448-0242	Clinton Hammond
Great Lakes Regional Waste Exchange 3250 Townsend NE Grand Rapids, Michigan 49505 (616) 451-8992	William Stough
Industrial Materials Exchange Service 2200 Churchchill Road, #24 Springfield, Illinois 62706 (217) 523-8700	Margo Siekerka
Industrial Waste Information Exchange New Jersey Chamber of Commerce 5 Commerce Street Newark, New Jersey 07102 (201) 623-7070	William E. Payne

Table 4-6 (Continued)

Organization/Address/Telephone	Contact person
Inter-Mountain Waste Exchange HATCHCO-W.S. Hatch Co. 643 South 800 West Woods Cross, Utah 84087 (801) 295-5511	Joe Parkinson
Midwest Industrial Waste Exchange Ten Broadway St. Louis, Missouri 63102 (314) 231-5555	Clyde H. Wiseman
Montana Industrial Waste Exchange P.O. Box 1730 Helena, Montana 59624 (406) 442-2405	Janelle Fallon
Northeast Industrial Waste Exchange 90 Presidential Plaza Suite 122 Syracuse, New York 13202 (315) 422-6572	Lewis Cutler
Piedmont Waste Exchange Urban Institute UNCC Station Charlotte, North Carolina 28223 (704) 597-2307	Mary McDaniel
Southern Waste Information Exchange Post Office Box 6487 Florida State University Institute of Science & Public Affairs Tallahassee, Florida 32313 (904) 644-5516	Gene Jones
Tennessee Waste Exchange Tennessee Manufacturing Association 501 Union Building, Suite 601 Nashville, Tennessee 37219 (615) 256-5141	Sharon Bell
Western Waste Exchange ASU Center for Environmental Studies Krause Hall Tempe, Arizona 85287 (602) 965-2975	Nicholas Hild, PhD

Table 4-6 (Continued)

Organization/Address/Telephone	Contact person
Materials Exchanges:	
Alkem, Inc. 25 Glendale Road Summit, New Jersey 70901 (201) 277-0060	Alan W. Schneider
American Chemical Exchange (ACE) 4849 Golf Road Skokie, Illinois 60077 (312) 677-2800	Tom Hurvis
Enkarn Research Corporation Industrial Commodities Bulletin P.O. Box 590 Albany, New York 12201 (518) 436-9684	J. T. Engster
Environmental Clearinghouse Organization - ECHO 3426 Maple Lane Hazel Crest, Illinois 60429 (312) 335-0754	William Petrich
ICM-Chemical Corporation 20 Cordova Street, Suite #3 St. Augustine, Florida 32084 (904) 824-7247	Anthony L. Tripi
New England Materials Exchange 34 N. Main Street Farmington, New Hampshire 03835 (603) 755-9962 or 755-4442	David Green
Ore Corporation, The Ohio Resource Exchange 2415 Woodmere Drive Cleveland, Ohio 44106 (216) 371-4869	Richard L. Immerman
Peck Environmental Laboratory, Inc. P.O. Box 947 Kennebunk, Maine 04047 (207) 985-6116	Donna Trask

Table 4-6 (Continued)

Organization/Address/Telephone	Contact person
TECHRAD Industrial Waste Exchange 4619 N. Santa Fe Oklahoma City, Oklahoma 73118 (405) 528-7016	Ernest L. Koerner
Union Carbide Corporation (In-house operation only)	
Zero Waste Systems, Inc. 2928 Poplar Street Oakland, California 94608 (415) 893-8257 or (415) 893-8261	Trevor Pitts

available or wastes wanted. Rather than listing the names of participating companies on the exchange, most information exchanges simply list a "box number," a procedure similar to that used in classified ads. This system ensures confidentiality to companies who fear that an analysis of their wastes would reveal proprietary information about their manufacturing processes. Information exchanges may be passive or active:

Passive Exchanges. Passive exchanges serve only as clearinghouses for information that could link two potential traders together. These exchanges work by publishing listings, usually in a quarterly bulletin. Interested parties send letters of inquiry regarding wastes listed by the exchange, which are in turn forwarded to the originator of the listing. The generator and potential user must negotiate directly to determine whether each party's negotiating requirements can be arranged, if not already satisfied. Passive exchanges often try to track the subsequent transactions, but because companies are often reluctant to reveal such information, not all successful exchanges are recorded (Sloan 1985).

Active Exchanges. Active information exchanges take an additional role in matching users and generators. Introductions of parties are made from interviews, during joint meetings, and through computer matching. Such exchanges employ a technical staff who attempt to "match up" the waste with a use upon its entry into the system. They contact companies directly to see if there is a need for the wastes, rather than waiting for responses to publication of the listings. Many information exchanges that were passive are taking a more active role and could now be classified as active exchanges (personal communication with Mr. Lewis Cutler, Director, Northeast Industrial Materials Exchange, December 13, 1985).

Sponsorship and Funding of Information Exchanges. Active and passive information exchanges operate as nonprofit and nonregulatory entities. Although some money is generated by the payment made by advertisers to list their wastes in the exchanges' publications, the income has not proved sufficient to maintain operation of the waste exchange (personal communication, William Sloan, Secretary, Maryland Hazardous Waste Facilities Siting Board, October 15, 1985).

Funding for both active and passive information exchanges generally comes from both government agencies and nongovernment organizations. Examples of funding sources include the following:

- The Northeast Industrial Waste Exchange receives money from the Manufacturers Association of Central New York, the Central New York Regional Planning and Development Board, the New York State Environmental Facilities Corporation, and the Ohio Environmental Protection Agency (personal communication with Mr. Lewis Cutler, Director, NIWE, December 13, 1985).
- The Midwest Industrial Waste Exchange is supported by the State governments of Missouri, Kansas, and Arkansas, and by the Tennessee Valley Authority.

At one time, the U.S. EPA had a role in promoting waste exchanges by providing information and advice on their operation to interested parties. EPA's involvement took place during 1980, but did not continue because of changes in emphasis to different programs. Recently, the Maryland Hazardous Waste Facilities Siting Board passed a resolution (October 17, 1985) that requires the Board to request the U.S. EPA to provide a portion of the funding required to maintain waste exchanges in the U.S.

Material Exchanges

There are two types of material exchanges: direct transfer and broker-assisted exchanges. The activities of privately-owned brokerages supplement the activities of material exchanges.

Direct Transfer Material Exchanges. Direct transfer material exchanges are arranged by chemical companies large enough to have departments devoted to maximizing the recovery of surplus and byproduct chemicals. Such companies transfer their wastes directly to other companies, often for a profit. Since some of these wastes may require treatment before they are sold, legal staff support and an onsite waste processing facility may be required for this type of exchange.

- One example of a direct transfer material exchange is the agreement between the Andrews Wire Company of Andrews, South Carolina, and Diamond Shamrock Corporation. Andrews Wire Co. generates approximately 1.5 million gallons per year of waste pickle liquor containing 10 to 15 percent ferrous chloride and 5 to 10 percent unreacted hydrochloric acid (HCl). In 1980, Andrews initiated a waste acceptance agreement with the Diamond Shamrock chromates plant in Castle Hayne, North Carolina. By this agreement, Diamond Shamrock accepts the pickle liquor without a fee, provided that the acid content of the liquor exceeds 5 percent. Diamond Shamrock uses the liquor to reduce hexavalent chromium compounds to trivalent chromium hydroxide in their treatment system (personal communication with Robert Johnson, Andrews Wire Co., Andrews, S.C., December 17, 1985).

- There are numerous other examples of such exchanges in the chemical industry between adjacent plants in which waste acids or alkalis from one facility are used to neutralize wastes from the plant "next door." Other examples include the sale of waste dilute sulfuric acid to nearby facilities for fertilizer production.

- Direct transfer material exchanges are most likely to occur between nearby facilities that have constant or nearly constant rates of waste generation and consistent waste compositions.

Broker-Assisted Material Exchanges. In broker-assisted material exchanges, all materials transferred pass through the exchange. Revenues are generated through commissions charged on transactions. Wastes that cannot be recycled directly are processed either by the material exchange itself or by a third-party as arranged by the exchange. Wastes that are difficult to "match" with a potential user are sometimes referred to a third party broker. Alternatively, the broker-assisted material exchange may locate a buyer for a batch of waste, which the buyer purchases from the generator for eventual resale.

Brokerages. Waste brokerages augment the activities of waste exchanges. Brokers are specialized in various waste "territories"; for example, some may be familiar with companies that use metals, while others may specialize in off-specification organic chemicals. In addition to working with material exchanges, a broker may negotiate directly with companies seeking purchasers of their wastes or by others who will buy a particular type of waste.

Although the efforts of waste brokerages may seem to duplicate those of information exchanges, the services of brokers actually complement those of the exchanges. Because the waste exchanges cover wider territories, the information provided by exchanges often is of use both to individual companies and to waste brokers. At the same time, a broker may have local information about companies or waste streams that is not available through information exchanges. Brokers themselves frequently consult the waste exchanges as sources of information (personal communication with Lewis Cutler, Director, Northeast Industrial Materials Exchange, December 13, 1985).

Limitations of Waste Exchanges

Although waste exchanges provide a mechanism for the direct exchange of wastes, there have been some problems with their operation. Some generators do not use waste exchanges because they are concerned about quality control and long-term liability. Also, actual waste transfers may be unsuccessful because the quantity of the waste is inadequate, the quality is unacceptable, transportation costs are too high, government regulations are prohibitive, or distance and availability make transportation difficult.

Another problem with waste exchanges has been the lag time between publication of the listings and successful transactions. To smaller companies, a timely turnover of wastes is important, since storage of hazardous wastes for more than 90 days onsite could require the company to obtain a TSD permit. Dependency of transactions on the success of a quarterly publication could defeat the purpose of recycling for such companies.

Sloan (1985) maintains that problems with waste exchanges may be attributable to both the "lack of promotion by the Exchange and State government [and] slowness on the part of industry." Although some wastes are not suitable for trading through waste exchanges because of low quality or purity, there is some evidence that more types of wastes could be exchanged than are now. A recent statistical analysis of selected manifests conducted by the Industrial Materials Exchange indicates that approximately 25 percent of wastes sent for land disposal in 1985 were suitable for recycling (personal communication, Margo Ferguson, Director, Industrial Materials Exchange, January 3, 1986).

The Industrial Materials Exchange analysis does not provide information on the constituents of the landfilled waste streams; volumes of waste landfilled per generator; and the distances from generator to available recycling facilities. Any one of these factors could cause a generator to decide not to recycle because of the costs involved or limited technical feasibility. The statistical information is significant, however, in identifying the fraction of wastes now landfilled that could be recycled and in pointing out the role that a waste exchange could play in changing that pattern.

Future Development and Uses of Waste Exchanges

Existing Information Systems. The problem stated above regarding lack of promotion by the exchanges themselves is beginning to be alleviated by some information exchanges' taking a more active role in contacting potential users of the exchange system. Rather than relying solely on the publication of the quarterly listings, some exchanges seek interested parties directly (personal communication with Lewis Cutler, Director, Northeast Industrial Waste Exchange, December 13, 1985).

On-Line Information Systems. Another recent development has the potential to advance significantly the usefulness of waste exchange programs, namely, the use of on-line computer services. Currently, both the Northeast Industrial Waste Exchange and the Industrial Materials Exchange use personal computers to maintain listings of wastes available and wastes wanted; these computer listings can be accessed on line. Companies now can place their own listings on the computer system, and the tracking of wastes available and wanted can be maintained much more accurately. Users calling into the system are not charged a fee; fees are charged only for companies placing advertisements or listings with the on-line computer system. A sample printout from the Northeast Industrial Waste Exchange is provided in Appendix D.

Listings requested can be sorted by region of the country and by type of waste. One drawback to the system is its current limitation in the size and number of computers. For example, the Northeast Industrial Waste Exchange computer has a capacity for approximately 400 listings. Another drawback is that the system is capable of accepting only one telephone call at a time.

There has been general interest in the use of this on-line system by other waste exchanges as well as by companies that have tried the system. Conversations with waste exchange personnel indicate that they eventually hope to expand the capacity of the system so that more callers can be accommodated and more listings can be maintained. Since listings are not limited to the geographical area that the exchange serves, the development of a national computerized waste exchange may be feasible through a jointly operated network. Furthermore, the rapid response available via the computer system would alleviate the lag time associated with quarterly publications. Finally, the attraction of more users may result in an increase in listings. Higher volume use of the system potentially could reduce the number of failed transactions, since a greater variety of waste types and qualities conceivably would be available to a greater number of companies.

Cooperative Arrangements

Companies may make cooperative arrangements with each other to facilitate recycling in ways other than the commercial batch-tolling agreements discussed earlier. Some case studies document arrangements between plants that are located near each other, and even between plants at some distance from each other. Stauffer Chemical's Baton Rouge plant furnishes fresh sulfuric acid to the Exxon refinery in Baton Rouge, then accepts the spent acid, reclaims it by reconcentration, and sends it back to Exxon (personal communication with Gordon Jolley, Exxon Chemical Americas, Baton Rouge Chemical Plant, Baton Rouge, Louisiana, July 8, 1985). An interstate, direct-transfer arrangement between Andrews Wire Company, Andrews, South Carolina, and Diamond Shamrock Corporation, Castle Hayne, North Carolina, was discussed above.

One example of a cooperative offsite recycling arrangement is that organized by the Neighborhood Cleaners Association (NCA). NCA delivers waste recycling "kits" to participating member establishments and, on a periodic basis, arranges for pickup of the accumulated wastes by a commercial recycling facility whose trucks service regular routes. Spent solvent (perchloroethylene) is recovered by distillation, cartridges are shredded, and any usable parts are recycled. Oily wastes that cannot be recovered are incinerated. The average cost for an NCA establishment to participate in this program is $600 to $700 per year (World Information Systems 1985).

There are several metal recovery cooperatives in operation that centralize recycling and other waste management by small generators. In each of these instances, a distributor or offsite facility makes routine "milk runs" to numerous small facilities to pick up hazardous wastes and resupply the facility with waste containers or other materials. Examples include:

- The Metropolitan Recovery Corporation, Minneapolis, Minnesota, is an organization of 20 printed circuit fabricators and metal finishing shops that will jointly manage all aspects of waste treatment for those facilities, including recovery, reuse, and disposal of metals and acid from wastewaters and finishing solutions. Ion exchange canisters will be provided to each generator. A public notice of the RCRA Part B application for the recovery facility is scheduled to be released in late September 1986.

- A working group of 30 generator facilities in the Cleveland, Ohio, area selected Tricil to operate a central ion exchange treatment facility for their wastes in Columbus, Ohio. The facility, scheduled for startup in late 1985, will service the Columbus and Cincinnati markets as well (personal communication with Donald Corey, Chemical Waste Management, Inc., Sommerville, Mass., August 9, 1985).

- Approximately 100 companies in the Metropolitan New York area (including Northern New Jersey and lower Connecticut) have formed a Metal Finishers Foundation. They are still exploring alternative technologies to ion exchange, and are actively negotiating for several alternative sites to locate the central metal recovery facility. Their target startup date is December 1987. Compliance schedules reflecting that date have been drawn up by regulatory agencies for some of the members.

  The group feels that they will overcome facility siting obstacles initially encountered. Concerns expressed regarding technical feasibility of ion exchange will presumably be addressed in their current technology evaluation work (personal communication with Donald Corey, Chemical Waste Management, Inc., Sommerville, Mass., August 9, 1985).

4.4 Future Extent of Recycling

The previous discussion of recycling suggests that there are companies not practicing recycling, but for whom the practice would result in cost savings. An increase in awareness of the economics of recycling may contribute to an increase in its practice by such companies.

One important factor that should result in an increased awareness of the economics of recycling is HSWA. The restrictions on the land disposal of certain hazardous wastes, coupled with increased technological requirements for new land disposal units, landfills, and surface impoundments, will limit the waste management options available to generators. For some wastes, land disposal may not be allowed; for others, the costs of land disposal may undergo substantial increases. These changes may motivate generators to consider alternative forms of waste management, recycling among them.

The potential for increased recycling will depend on the costs of alternative management techniques, for example, incineration, wastewater treatment, and underground injection (the latter may be allowed in limited instances). If treatment and disposal costs increase, those companies for whom recycling has been only marginally economical will find it becoming more attractive. Another reason for a possible increase in recycling is that some landfills may be closing because of an inability to comply with the new monitoring and technological requirements (personal communication with Jacqueline Tenusak, U.S. EPA, Office of Solid Waste, January 12, 1986). The scarcity of landfills, combined with the decrease in demand for landfilling because of land disposal restrictions, is likely to result in an increase in demand for waste management alternatives; the increase in the costs of landfilling may also contribute to the increase in demand for other forms of waste management.

Other factors that may contribute to an increase in recycling include:

- Feedstock Costs. If feedstock costs rise, companies will tend to seek higher efficiency in the use of raw materials or will seek substitute raw materials. Major feedstock categories include:

- Petroleum. Costs are not expected to increase and may decline in the near term.

- Natural Gas. The price of gas may increase locally as old contracts expire. Prices for natural gas in some old contracts are as low as $0.50/per million cubic feet (MCF). Prices in new contracts may be in the $2.00 to $3.00/MCF range. Companies most severely affected would be chiefly Gulf Coast plants holding long-term (10 to 20 years) contracts initiated in the 1960s and 1970s, which are now expiring (Chemical Week 1985a, b). The implication of this development is that there may be an increased use of waste solvent burning for fuel and internal recycling in processes that use natural gas as a feedstock, such as the production of ammonia and hydrogen cyanide.

- Electricity. Costs could rise because of nuclear plant cost overruns and increases in natural gas costs resulting from expiration of older contracts (Chemical Week, 1985a, b). This would imply that there may be an increase in internal recycling where such practices would result in savings in energy consumption, such as in the chloralkali industry and in other industries (e.g., the aluminum industry) having high electric power demands. However, the recent drop in oil prices may offset this increase if it results in lower fuel costs.

- Metals. Although the market for some metals is currently depressed (Chemical Week 1985c,d), a shortage could result in substantial increases in costs. This situation could provide significant incentives for increases of in-plant and offsite metals recovery.

- Foreign Competition. The effects of increased competition from foreign products could lead to greater domestic production, thus resulting in a need for companies to enlist cost minimizing measures. Recycling practices would be one avenue to reduce costs, although this approach may be offset by concern for product quality. The use of recycled materials may result in an inferior product (or one that is perceived to be so). Some of the factors affecting increased foreign competition include:

  - New petrochemical plants in the Middle East and OPEC countries have discounted feedstock costs for crudes.

  - Industrialization is continuing in developing countries.

  - The U.S. dollar continues to be high abroad, but is dropping against some currencies.

  - Present foreign competition for steel and manufacturing segments is strong.

- New Technologies. The increase in demand for treatment and recycling technologies may also spur a growth in the development of innovative onsite technologies and alternative new processes based on emerging technology (e.g., membrane separation). The demand for such technology would probably be greatest among smaller businesses who may lack in-house expertise to develop or run such technology provided they have the ability to pay for it. Potentially, market competition may drive prices down as well. The market for innovative recycling technologies would last until the market was saturated or until competition from technologies other than recycling increased. At this point, prices would again increase.

- Replacements of Old Technologies. Old processes, such as the mercury cell process for chlorine and caustic soda production, slowly are being phased out of existence as older plants are closed and new facilities based on membrane cell technology are opened. The new facilities rely on internal recycling as part of the production process and in some cases (such as the membrane cell process) do not generate any hazardous waste. Thus, the replacement of old facilities by new ones for this production process necessarily results in an increase in waste minimization.

- Illegal Disposal. Although there may be opportunities for an increase in recycling, there may also be a potential for increased incidents of illegal disposal. With the cost of landfilling potentially increasing because of increased technological requirements, generators may look to other options. In conjunction with increasing costs, treatment standards or bans may also be imposed for various hazardous wastes. Generators who are concerned over liability (due to the court's interpretation of the liability provisions of CERCLA) may be reluctant to ship wastes offsite for treatment or recycling. However, some companies may not be large enough to afford to audit the treatment or recycling facilities. Being small, they may also lack the in-house expertise to conduct such practices onsite. As a result, there may be a class of generators for whom illegal disposal may appear to be an option.

In addition to possible increased investments in onsite technology, some generators also are likely to form cooperative waste "pooling" arrangements in which volumes of similar waste streams are combined to collect a sufficient volume to make recycling economical. Distance to recyclers and small individual volumes of waste materials may make it otherwise uneconomical for smaller companies to recycle. Furthermore, waste pooling cooperatives could realize a cost savings in joint auditing of a commercial recycling facility. For these reasons, there also may be an increased demand for central recovery facilities for metal or solvents, as discussed in Section 4.3.

Waste exchanges will continue to play a significant role in facilitating reuse of wastes as alternatives to landfilling are sought; the adoption of on-line computer information systems by some waste exchanges is likely to enhance their role as well as the overall extent of recycling.

Finally, companies' concerns over increased regulatory requirements for recycled hazardous wastes and future liability for damage due to spills and accidents during transportation or handling hazardous wastes offsite may result in an increase in internally recycled waste streams. (The relationships among regulations, concerns for liability, and other factors that affect the promotion or inhibition of waste minimization practices are discussed in detail in Section 5.) The increase in such practices could be achieved by retrofitting facilities. Because it involves changes in design and operation, however, retrofitting existing facilities can sometimes be more expensive than incorporating such features during the design and planning of a new plant. In the long term, it is likely that the extent of onsite recycling will be dependent on the replacement of older facilities by new ones.

4.5 Summary

This section has identified the distribution of hazardous waste recycling in the United States by industries and according to the types of waste streams generated. Considering the wide range of available technologies for reclaiming many metal-bearing and corrosive solutions and spent solvents, the patterns of recycling such waste streams by high volume generator industries apparently are defined by a number of factors. Distinctions among major industries that recycle or do not recycle their wastes can be made on the basis of the type of industry (and associated waste generation processes); the total volume, uniformity, and constituent concentrations of the waste streams; and the identification of uses or reuses for the untreated or treated waste or reclaimable constituents. Some observations made in this chapter that highlight industry-specific factors include the following:

- Three manufacturing industries, the Transportation Equipment industry (SIC 37), the Chemical and Allied Products industry (SIC 28), and the Primary Metals industry (SIC 33), accounted for 89 percent of the total volume of hazardous waste recycled during 1981. In contrast, generators in the Motor Freight Transportation (trucking) and Warehousing industry (SIC 42) did not report any recycling of their wastes either onsite or offsite (RIA Generator Survey).
- Of the total volume of hazardous wastes recycled by all industries in 1981, approximately 81 percent were recycled onsite and less than 19 percent were recycled offsite.

- The breakdown of volumes of hazardous waste recycled according to onsite and offsite recycling (Table 4-1) suggests that the volume of waste recycled onsite increases as the total volume of waste recycle increases (i.e., facilities that recycle larger volumes of wastes are more likely to recycle onsite than offsite). Small quantity generators, on the other hand, are more likely to ship wastes offsite for recycling (Ruder et al. 1985).

The types of hazardous waste streams that are recycled in the greatest volumes are dilute waste streams whose constituent reuse is appropriate in large-scale applications within the generator industry. This is true for the three highest volume waste streams recycled during 1981:

- Spent acids and alkaline solutions (corrosivity characteristic wastes, D002), recycled in large volumes by the Chemical and Allied Products industry (SIC 28) and the Machinery-Except Electrical industry (SIC 35);
- Wastewater treatment sludges from electroplating (F006) and chromium plating solutions (D007), recycled in large volumes onsite by the Transportation Equipment industry; and
- Pickle liquor (K062), a corrosive, metal-bearing waste, recycled mainly by the Primary Metals industry (SIC 33).

These four waste streams together made up 49 percent of the total volume of waste recycled during 1981 (RIA Generator Survey).

The uniformity of a waste stream is an important determinant of both the technical and economic feasibility of recycling and reuse. Generators whose spent solutions or sludges are contaminated with multiple constituents that are difficult to separate from each other may find reclamation impractical. This problem may account for the relatively low volumes of solvent waste streams that are recycled, in particular those generated from the cleaning of multiple contaminants from equipment. Similarly, constituents of halogenated organic waste streams, such as polyhalogenated dibenzodioxins and dibenzofurans that are toxic at very low concentrations, limit the recycling of some organic waste streams.

Other observations related to the characterization of recycled waste streams include:

- Market demand for and the purity of the recoverable material determine the suitability of the waste for recycling; and
- The higher the weighted average concentration of known constituents in a waste stream, the more probable the selection of recycling as a waste management option.

The technology-specific profile outlined a number of physical and chemical treatment options. The following technologies dominate the recycling profile:

- Distillation of solvent wastes;
- Dechlorination of halogenated (nonsolvent) wastes;
- Various metal concentration techniques used alone or in combination on dilute metal-bearing waste streams; and
- Neutralization of corrosive wastes.

The technologies available for cyanide/reactive wastes are limited, although high volumes of wastewater sludges from electroplating operations are recycled.

Although not as common as onsite recycling, offsite recycling is the preferred option for some generators, in particular the Primary Metals industry (SIC 33) and small quantity generators (SQGs) of lead-acid battery wastes. Commercial recycling facilities operate under a number of arrangements with generators depending on the market value of the waste and other factors. The offsite recycling profile includes mobile facilities that recycle solvents and PCB-contaminated wastes either at a central recovery facility or other commercial recycling facility.

Transfer of wastes that are not of potential use to the generator but may be suitable raw material for another industry is facilitated by the listing of such wastes in waste exchanges. Some features of waste exchanges highlighted in this section include the following:

- There are two types of waste exchanges available:
  - Information exchanges that serve as clearinghouses listing "wastes available" and "wastes wanted."

  - Material exchanges that may participate in the actual transfer of wastes. Waste brokers are also available to provide information regarding wastes available and companies wanting specific wastes.

- Wastes currently recycled through waste exchanges include acids, alkalis, other inorganic chemicals, organics and solvents, metal wastes, and corrosives. Of the total wastes listed, from 20 to 30 percent are eventually exchanged.

- The advent of on-line computer information systems by some waste exchanges and the increasingly active role of information exchanges in locating suitable generators and users of listed wastes indicate a potential growth in the types and volume of waste recycled via waste exchanges.

A number of case studies were presented, which illustrate the potential for organized groups of small volume generators to recycle their hazardous wastes at central recovery facilities. Such cooperative arrangements benefit the individual generators by spreading out the capital investment and operation costs among them.

The future extent of recycling will be influenced by a number of economic, technical, and regulatory factors. Among the factors most likely to result in an increase in the volume of hazardous waste recycled are the following:

- An increase in the awareness of the economics of recycling;
- Restrictions on land disposal imposed by HSWA;
- Increases in feedstock costs, including fuel and raw materials;
- Increases in foreign competition;
- New technologies to fill the demand for onsite treatment technology;
- Replacement of older production technologies by newer technologies that rely on internal recycling as a component of the production process; and
- Increased regulatory requirements for recycled hazardous wastes shipped offsite.

Contributing to a possible decrease in volumes of waste recycled are increased regulatory requirements. The increased requirements and liability issues may cause some generators to view illegal disposal as an option.

5. FACTORS THAT PROMOTE OR INHIBIT WASTE MINIMIZATION

Many factors contribute to a company's decision to employ waste minimization practices; however, the most notable pertain to (1) whether it is economically viable to do so and (2) whether such practices are technologically feasible.

Another factor that is equally important is the support for such programs within the firm, particularly from upper management. To be successful in bringing about changes in plant operation and/or design, policy-making and implementation processes within companies are largely dependent upon upper management support. Pressure exerted by the public, who may perceive that its health is being threatened by a company's operating practices, also plays a significant role.

An industry's perception of the laws and regulations that govern it is another factor in the decision-making process. The limitation of alternatives by regulation dictates waste management choices, with the ultimate decision being the one that offers (or is perceived to offer) the "greatest good." The potential land disposal bans, which are a direct result of the Hazardous and Solid Waste Amendment of 1984 (HSWA), may provide major impetus for considering waste minimization practices.

This section identifies and analyzes the factors that may promote or inhibit waste minimization, focusing on:

- Economic issues;
- Liability aspects;
- Attitudinal issues;
- Consumer awareness and public relations aspects; and
- Regulatory issues.

5.1 Economic Aspects and Technological Innovation

In this section, the economic parameters affecting a firm's decision to invest in innovative technology are analyzed, with an emphasis on investments in source reduction and recycling projects. The discussion will address both the incentives and the disincentives for making these types of investments. The balance of this section is devoted to:

- A firm's decision to invest;
- Investment in innovative technology; and
- Investment in waste minimization.

5.1.1 A Firm's Decision to Invest

In the macroeconomic sense, there are two types of investment -- investment to maintain the capital stock and investment to enlarge the capital stock. Investments to maintain the capital stock are frequently associated with industries in which no new technology is being developed. The definition of new technology includes innovations that reduce the costs of production, improve product quality, or lead to new products. Investments that enlarge the capital stock are often associated with industries in which research and development, competition, or regulatory pressure have fostered the development of innovations that reduce the costs of production or improve product quality.

From the point of view of the individual firm, the ultimate objective of investment activity is to increase its earnings and thereby increase owner or shareholder wealth. The decision whether to invest is a function of, among other things, the investment's expected rate of return and the market interest rate. All other things being equal, a firm can justify an investment in waste minimization technology if the present value of the resulting cash flow is greater than the current cost of the investment. This means that the firm will increase its wealth by undertaking the investment. The cost of the investment depends, in large part, on the market rate of interest. As the market rate rises, investing becomes more costly.

Some of the issues that cloud the decision-making process include (1) the ranking of investments in waste minimization in the context of a limited supply of capital, (2) the ability of a firm to raise capital for investment, and (3) the true cost of capital to the firm. The ranking of alternative investment opportunities is frequently accomplished by calculating the payback period, the net present value, and/or the internal rate of return. These methods of profitability analysis are described in Section 5.1.3. Smaller firms are generally not able to raise as much capital as larger firms and thus face a greater constraint on their overall investment capabilities.

To evaluate a firm's cost of capital, it is necessary to consider the firm's sources of capital, as well as its capital structure. Sources of capital for a corporation include:

- Long-term debt or bonds;
- Preferred stock;
- Common stock; and
- Retained earnings (profits after taxes plus dividends withheld).

There is motivation for investment in waste minimization when the cost of reducing waste is less than the cost of producing the present amount of waste minus the cost of producing a lower, future amount. (Specific cost categories where savings may be realized are outlined in Section 5.1.3.) In other words, the cost to the firm must be less than the benefit derived. Moreover, firms can improve their competitive position through waste minimization, if waste generation costs represent a significant portion of their manufacturing costs.

The economic parameters influencing investments in source reduction programs also influence recycling investments. As illustrated below, however, other factors emerge as relevant to recycling program investment decisions.

Economies of scale (the reduction of unit costs of production through expansion of the scale of operations) invariably have limited onsite recycling to large waste volumes, with small quantities consolidated for recycling at offsite facilities. As offsite facility charges rise to reflect increased operating and regulatory compliance costs, generators are able to economically justify onsite recycling of moderate-volume streams. At the same time, EPA's reduction of the exemption levels of most hazardous wastes to 100 kg/month has created a new class of very small hazardous waste generators, who must depend on offsite recycling facilities in order to survive economically. In response to the new regulation and in order to create economies of scale, the Neighborhood Cleaning Association (NCA), representing 1,400 dry cleaning plants, organized a recycling program for its members. The average dry cleaning plant spends $600 to $700 a year on the NCA's recycling program. This program is described in further detail in Section 4.3.3.

Small metal finishing operations are another example of small waste generators who have implemented recycling programs by creating economies of scale. For these metal finishers, it is not economical to install full wastewater treatment facilities to meet industry pretreatment effluent guideline standards. Instead, trade associations in several geographic areas are attempting to set up regional recycling programs. These programs will concentrate hazardous waste, using less costly package equipment in each metal finisher's shop for routine pickup and recovery by an offsite recycling facility.

Purity requirements for chemical feedstocks also have a bearing on the acceptability of recycled materials. Those companies that purchase the higher quality chemicals are less likely to attempt recycling efforts, because the recycled materials may not meet their processing specifications. In addition, the small quantities of waste available from such generators are of little economic value to companies that have secondary, less-critical process uses. An offsite facility servicing a large number of those small generators could reclaim a product that was reasonably consistent in quality, however. The salient market consideration would then be whether sufficiently large quantities can be processed to be of commercial value to secondary users.

5.1.2 Investment in Innovative Technology

A firm's decision to invest in waste minimization may involve the development and/or application of innovative technologies. In the context of an investment decision, the factors affecting the development of innovative technologies are also those that influence the application of existing innovations. These factors are summarized below:

- Profitability and Risk. Profit and risk are the primary factors that determine the rate of investment in innovative waste minimization technologies. If the investment presents a high risk, it must have a corresponding high return to justify the capital outlay. The first firm to develop and implement a new technology may reap competitive advantages. The prospect of higher returns from competitive advantage can serve to justify the greater risk of investing in research and development or the technological risk associated with adapting a new, previously untested technology. Overall, the higher the profit and the lower the risk associated with an innovative waste minimization technology, the higher is its rate of adoption.

- Cost of the Innovation. Cost is also a major determinant of whether a new waste minimization technology is adopted. Expensive innovations are less likely to be adopted, because a firm tends to be more cautious when it comes to making large capital expenditures (Mansfield 1982). Alternatively, lower-cost innovations requiring less capital and involving less risk are more quickly adopted.

- Capital Availability Due to Competing Investment Opportunities. The availability of capital also influences a firm's decision to invest in innovation. Firms able to obtain sufficient capital at acceptable cost are in a better position to implement new waste minimization technology. As noted above, more innovation will occur if the innovations are relatively inexpensive to adopt.

- Availability and Stage of Development of the New Technology. Sufficient supporting scientific theory and applied research help to encourage the innovative process and can influence positively the adoption and diffusion of an innovation. If waste minimization technology exists and can be easily adapted to the firm's production needs and does not interfere with product quality, it is less costly and less risky than technology that requires further development. For the existing developed technologies, the problem of technological availability translates into a problem of availability of sufficient technical information detailing the engineering description and application history.

- Market and Regulatory Factors. To justify an investment in a new process or product, there must be adequate demand for the existing or eventual product in the marketplace. In most cases, if product demand is not adequate the firm has little incentive to invest in innovation. A decrease in demand, however, also can lead to investment in innovation, especially if the investment will reduce the unit cost of production and the decrease in demand is due to price competition from other firms. In addition, a change in market requirements, such as the reality or the possibility of an outright ban on certain chemical constituents in the products, can serve as an incentive to invest in waste minimization. Generally, market forces, such as inelastic demand for the product and price competition from firms that have already invested in the innovation, will provide an incentive to invest in new waste minimization technologies. However, highly elastic demand for the product, or the failure of other firms to invest in the innovation, will tend to discourage investment in new waste minimization technologies.

- Internal Production Factors. These factors also influence the decision to invest in innovative waste minimization technologies. They include:

  - High production costs/low profits;
  - Equipment age; and
  - Problems with maintaining product quality.

  A firm may decide to invest in an innovation if it solves an internal production problem and improves the firm's profits and competitive position. If a firm's capital equipment is relatively new, the firm is less likely to apply new waste minimization technology than if its equipment is older and fully depreciated. If the innovation will lower production costs or improve product quality, the firm has an incentive to innovate. These factors also may be interrelated. For example, old equipment may result in quality assurance problems and high production costs. These types of production problems tend to influence the rate at which firms adopt existing innovations rather than motivate the development of new technical innovations, however (Rosenberg 1982).

In summary, the development or adoption of innovative waste minimization technology is influenced by a combination of factors, some of which are beyond the control of the firm and some of which are internal to the firm. The ultimate decision by a firm to invest, however, will be made only after a thorough analysis of the profit and risks associated with the innovation.

5.1.3 Investment in Waste Minimization

Identification of Specific Waste Generation Costs

One of the compelling incentives for investing in waste minimization technologies is the increasing cost and, in some cases, the banning of land disposal of hazardous wastes. Costs associated with the generation of hazardous wastes are an element in a firm's unit cost of production. Waste generation cost per unit of output is a function of waste generation cost per unit of waste generated and the waste-to-output ratio, as follows:

$$\frac{\text{waste cost}}{\text{unit of waste}} \times \frac{\text{unit of waste}}{\text{unit of output}} = \frac{\text{waste cost}}{\text{unit of output}} \qquad (1)$$

Equation (1) shows that a producer can control the impact of waste generation on unit production costs by (a) reducing the cost associated with the generation of each unit of waste, or (b) generating less waste per unit of output. If the costs of waste generation lie, in large part, outside of the direct control of waste generators, then there is an incentive to reduce the ratio of waste to output through investments in waste minimization.

The costs of waste generation are dependent on the costs of its associated waste management. The balance of this section provides an overview of the potential costs incurred by a firm caused by hazardous waste generation. These types of costs are summarized in Table 5-1.

- Waste Disposal. These costs include fees charged by treatment/disposal facilities plus any applicable State fees and taxes. Many States levy fees and/or taxes that may vary according to the volume and type of hazardous waste generated, the size of the generator, and/or the method of waste management. Waste reduction can produce a direct savings in the form of avoided facility fees and avoided State fees and taxes (see Section 7.4 for more information on State fee and tax systems).
- Waste Transport. Costs for long-distance hauls (excluding local pickups within 25 miles) are generally in the range of $1.50 to $3.00 per vehicle per

Table 5-1 Costs Associated with Hazardous Waste Generation

Waste generation cost category	Type of cost Capital	 Operating
Waste disposal (incl. fees and taxes)	X	X
Waste transport	X	X
Waste storage prior to transport (e.g., equipment and handling cost)	X	X
Environmental compliance equipment and predisposal treatment	X	X
TSD permits (incl. cost of certifying waste minimization)		X
Reporting on waste minimization activities		X
Waste manifesting		X
Emergency preparedness and cleaning	X	X
Pollution liability		X
Excess materials and processing costs		X

running mile, depending on a number of variables. This has the greatest effect on small generators located a substantial distance from offsite facilities. There is, in effect, an economic barrier to offsite disposal and recycling for small generators--the relatively high unit cost of transporting small volumes of waste long distances. For larger generators who transport their own wastes, the transportation costs associated with waste minimization are lower per unit of waste volume.

- Waste Storage Prior to Transport. Waste storage requires a commitment of labor, land, and equipment resources by the firm. Space, which could have more productive uses, must be set aside. Machinery and personnel are required for collecting wastes, moving drums within the plant, and loading them onto trucks. Smaller volumes of waste can mean fewer resource commitments to storage and handling operations. It can also mean savings in cost from the avoided purchases of equipment, as discussed below.

- Environmental Compliance Equipment and Predisposal Treatment. This category represents a significant cost of waste generation. Cost savings to the firm from waste minimization can take the form of avoided purchases of compliance equipment or of lower treatment costs resulting from the smaller volume of waste to be treated. For example, a manufacturer of stationary power equipment installed an oil skimmer and ultrafiltration system that reduced the organic load to the wastewater treatment system, resulting in a $10,000 annual savings in treatment costs plus a savings in the form of avoided installation of additional treatment capacity (Huisingh 1985).

- TSD Permits. Obtaining treatment, storage, or disposal (TSD) permits, reporting at least biennially on waste minimization activities, and manifesting waste are requirements imposed on firms by RCRA and HSWA. Firms have to commit significant personnel and time to meeting these requirements. TSD permits can be avoided only if no treatment, storage, or disposal activities take place within the battery limits, which implies that wastes must be shipped offsite or recycled/reused onsite within 90 days. The reporting requirement remains as long as a firm is a designated generator. The preparation of manifests and tracking of waste can be lessened if the volume of waste going to offsite facilities is reduced.

- Emergency Preparedness and Cleaning. Firms must carry fire and accident insurance, employees must be specially trained to deal with hazardous substances, and special protective equipment may be required. As an example of cost savings in emergency preparedness, an engine painting facility switched to water-borne coatings to reduce its solvent waste, and ended up reducing its fire insurance premiums as well (Campbell and Glenn 1982).

- Pollution Liability. Firms qualifying as (TSD) facilities are required by Federal regulations to carry liability insurance or to maintain sufficient assets to handle claims independently (40 CFR 264.147(a) and (b)). The cost of EIL coverage depends, therefore, on the exposure of a firm to current claims resulting from past, as well as present, hazardous waste generation and disposal practices. Consequently, firms with a lengthy history of landfilling persistent hazardous wastes should not expect EIL premiums to fall in the short run on the basis of current reductions. The potential for reducing premiums in the short term through waste minimization is greatest where the generator's facility is relatively new and free from latent liabilities (Humpstone 1984).

- Raw Materials and Processing. The reduction of waste also implies a higher product yield per unit of input. For a given production level, less input is required, producing a savings in material purchases and processing costs to the firm. Perhaps the most familiar example of reduced materials costs resulting from waste minimization is the onsite recycling and reuse of solvents. For example, a manufacturer of specialized labels installed a distillation unit to recover alcohol solvent from waste inks. The unit, while reducing disposal costs by 74 percent, also reduced raw materials costs by 16 percent (Huisingh 1985).

Waste minimization projects may not affect all of the cost categories identified above; rather, the identified categories should be used as a guide to where savings can be realized through waste minimization.

Project Analysis

The crucial question in making an investment in waste minimization is "How much will the investment return to the firm?" To answer this question, methods are required for evaluating the profitability of the investment and comparing it to other investment opportunities.

Three popular methods for evaluating a project's profitability are presented: payback period method, net present value method, and internal rate of return (the last two methods belong to the family of discounted cash flow methods). These are discussed in further detail in Appendix E.

5.2 Liability Aspects

The risk of future liability plays a significant role in the decisions of many companies in the handling of their hazardous wastes. Responses by company managers recorded in a study by Savant Associates (1984) and observations by participants in a conference on recycling and procurement (Kerr 1985a) indicate that managers respond to the perceived effects of the joint and several, strict, retroactive, and absolute liability provisions employed under the Comprehensive Environmental Response, Compensation Liability Act (CERCLA, commonly known as Superfund) (Sections 106 and 107) and the common law doctrine. Generators' concern over future liability (associated with the liability provisions of CERCLA) may provide an incentive for considering onsite recycling. Onsite recycling may not be viable for companies lacking the in-house expertise to perform such activities, however. Also, some companies may perceive onsite recycling as an undesirable venture into another business (National Research Council 1985).

5.2.1 Inability to Obtain Insurance

Many companies doing business with recyclers are concerned as to whether the recycling companies have adequate access to potential liability insurance. This concern arises because an offsite recycling facility could cause environmental damages resulting in liabilities in excess of the recycler's financial capacity and insurance limits. Under Section 107(a) of CERCLA, the generator potentially could be subject to pay for damages caused by the recycler. Thus, where recycling companies are inadequately insured, the potential future risk to companies sending their wastes to the recyclers increases. For those companies with the capacity to self-insure, there is thus a substantial incentive to dispose of wastes onsite, rather than to recycle offsite.

Over the past several years, the cost of all forms of commercial liability insurance has risen sharply, while its availability has been sharply reduced. Premiums have increased 50 to 300 percent, policies have been cancelled even where loss ratios have been excellent, and many companies have difficulty obtaining coverage at any price. This is particularly true of pollution liability coverage (environmental impairment liability (EIL) insurance), which until 1985 was a popular financial instrument used by generators and owners of TSDFs to protect themselves from third party and government claims for damages resulting from releases of hazardous substances to the environment. During the past two years, the number of insurance companies offering non-sudden pollution liability insurance has been reduced from 14 to 7 (Telego 1986). Of those 7, only 2 write pollution insurance on a stand alone basis. The other carriers write pollution on an accommodation basis through a pooling concept, as a licensed single carrier, or as a captive insurance company. Those insurers remaining in the market have both reduced capacity and substantially increased premiums and have developed restrictive terms and conditions within their pollution insurance policies. Pollution insurance markets currently writing third party liability insurance on a monoline basis (stand alone) for non-sudden/gradual and sudden and accidental occurrences include the American International Group and St. Paul Fire and Marine Insurance Company. The Pollution Liability Insurance Association (PLIA) (a reinsurance pool of 25 members), Travelers, Aetna, Wausau Insurance Company (recently merged with Nationwide and also a member of PLIA), and Firemans Fund are the only known carriers that will write pollution insurance on an accommodation basis for customers who have other lines of insurance with them (Telego 1986, Telego 1985, Finlayson 1985a and b). PLIA will provide limits of pollution insurance only for its member companies and their clients. Continental Insurance will be writing pollution liability insurance on an accommodation basis in mid-1986.

Analysts of the insurance industry do not see any near-term prospects for improvement of the availability of environmental impairment liability coverage until mid-1988, or not until CERCLA is amended to (1) limit liability, (2) eliminate the joint and several liability interpretation, and (3) require some type of toxic tort reform in State common law. With respect to item (3), insurance analysts would want changes so that case law will have a less adverse effect (in the opinion of the analysts and potential insured) on the insurance industry.

Insurance analysts attribute the withdrawal of pollution insurance from the marketplace to the factors outlined below (Telego 1985, Telego 1986, Finlayson 1985a and b):

- Courts have and continue to interpret insurance policies in favor of the insured in a vast majority of coverage disputes.
- Courts continue to impose joint and several, strict, and absolute liability under the doctrine of common law and under Superfund (unless Superfund is amended).
- The underdeveloped actuarial data base overlapping Federal and State statutes is affecting underwriting procedures and results. Primary and reinsurance carriers experienced their worst underwriting results in 1984 (loss of $3.5 billion) since 1906.
- Insurers exhibit little confidence about the predictability of pollution risks; therefore, underwriting is extremely uncertain.
- The lack of a developed actuarial data base, (as perceived by insurers) from which to price and reserve against unforeseen losses leaves underwriters with few options to protect net worth and shareholder surplus.
- The lack of technical data, uniform risk assessment guidelines, industry-written underwriting guidelines, and the absence of mechanisms for transfer and use of those data to insurers regarding disposal of hazardous substances at treatment, storage, or disposal sites, increase uncertainty and potential liability.
- Adverse selection brings the most severe risks into the market.
- Possible long-term effects from long latency of an exposure or environmental damage increase uncertainty.
- The multiple-exposure effect subjects reinsurers to exposure under numerous policies.

The major reason for the current insurance capacity shortage is the insurance underwriting cycle. In the late 1970s and early 1980s when interest rates were at their highest, two factors made it possible for insurance companies to maximize the range of coverage offered: (1) the direct interest earnings of the companies themselves, and (2) the volume of reinsurance offered by overseas companies attracted by the high U.S. interest rates. At this time, most of the reinsurance was retroceded to the London marketplace through domestic and foreign reinsurers.

While interest rates were high, many insurers made an effort to attract customers by writing premiums and policies that were underpriced and inadequately covered by reserves (cash flow underwriting). Such policies were secured against losses suffered on those policies by high earnings on interest income. When interest earnings fell in late 1983 and early 1984, many companies were left with insufficient interest earnings to offset their losses or potential claims/losses on such policies. In order to reduce their exposure, they simply ceased providing coverage where losses seemed least predictable, or where the premiums that would have to be charged to protect against that uncertainty seemed too high for the market to bear. Numerous reasons caused reinsurers to leave the pollution marketplace. Among them were the decline in interest rates in the U.S. and the judicial determinations on old CGL policies. These factors directly caused losses disproportionate to the amount of premiums retroceded because of low primary retentions and low premium rates for higher layers. The catastrophic nature of environmental losses would consume the excess or reinsurers' layers. The result was a substantial shrinkage in the amount of insurance capacity primary carriers could offer potential insureds. Capacity dropped from a high of $165 million in coverage offered in 1983 to a maximum $10 million in coverage today, with limited excess capacity. The only possible excess capacity being developed may be through offshore captives (mutuals, stock, reciprocal exchanges, and future syndicates/pooling arrangements).

While none of these difficulties are necessarily irresolvable, the apparent tendency toward high awards and broad judicial interpretations of the extent of coverage in liability litigation has made insurance companies increasingly leery of such policies. There have been recent court cases, such as that in Jackson Township, New Jersey, in which the potential for loss of quality of life (absent any current injury), provided the basis for financial awards. Such decisions have made many in the insurance industry feel that the potential exposure is far too high to be met by any feasible premium level.

One possible result of this situation is that companies that can self-insure may have access to stop-loss insurance, if it is available. Many recyclers, however sound their operations, may not be large enough to be able to self-insure. This provides generators with an added disincentive to risk becoming involved with an offsite recycler.

To meet this problem, some companies and associations are attempting innovative approaches to secure adequate insurance. Self-insurance is only one of many alternatives, however. Companies are also looking to form association stock and mutual captives, risk retention and purchasing groups, self-funded insurance with stop-loss excess insurance, and retroactively financed plans. In one case, members of an association are approaching potential insurers to front their program, hoping that the lure of the insurance premiums/commissions from the members will provide adequate incentive for the insurer to write policies for each of the member companies. Ideally, this could involve an arrangement whereby basic coverage would be provided by the captive, which would purchase higher levels of coverage from a reinsurer, if reinsurance can be found. The reluctance of reinsurers, however, to deal with environmental liability means that such captives may have to be fully funded up front by the company or companies involved, and not all companies can afford such a capital outlay. There are also other difficulties involving capitalization, loss reserving, loss prevention, and general administration to the captive.

5.2.2 Cleanup Costs

As discussed in the previous section, the cost of cleaning up a hazardous waste site is a potential liability. In order to minimize risks of liability for future cleanups, some firms may be encouraged to invest in source reduction (which reduces the amount of waste generated and for which a company may be liable) and onsite recycling programs (which reduce the amount of wastes shipped offsite). To determine the extent to which liability for cleanup costs promotes waste minimization, it is necessary to answer two questions. First, how do firms perceive their responsibilities for waste minimization in light of current Federal regulations? If firms understand that the law will require them to clean up hazardous wastes, this prospect of liability for cleanup would be expected to promote waste minimization. (This question is the subject of Section 5.3, Attitudinal and Organizational Aspects.) Secondly, what are the costs associated with the cleanup of a hazardous waste site? These costs must be clearly delineated before they can influence investment decisions.

Because cleanup costs are such a critical issue for waste minimization investment decisions, it is important to develop a model of the costs associated with remediating a hazardous waste site. The diversity that exists among waste sites and treatment technologies, however, makes it difficult to create a representative cost model. For example, in the past a large number of waste sites have been landfills. Relative to other sites such as chemical or manufacturing plants, landfills have a low degree of variation in cost. Nevertheless, there are substantial differences among landfills in terms of size, topography, extent of subsurface contamination, leachate formation, proximity to houses and wells, and degree of ground-water contamination.

In addition, there exists a high degree of variation among hazardous wastes. Wastes can be distinguished not only by quantity, but also by biological impacts (degree of toxicity, carcinogenicity, mutagenicity, teratogenicity, and subchronic and other toxic effects) and by physical and chemical features (such as their physical state, mobility, reactivity to surrounding chemicals, ignitability, and corrosivity).

Finally, there are numerous types of treatment technologies. These technologies can be classified into three categories: physical, chemical, and biological. Table 5-2 lists some of the treatment technologies that were identified in a 1977 EPA study (U.S. EPA 1977).

In light of these variations in hazardous waste site cleanup costs, the balance of this section is devoted to identifying and modeling the main elements of cleanup costs.

Table 5-2 Treatment Processes Identified

Physical

- Air stripping
- Suspension freezing
- Carbon adsorption
- Centrifugation
- Dialysis
- Distillation
- Electrodialysis
- Electrophoresis
- Evaporation
- Filtration
- Flocculation
- Flotation
- Freeze crystallization
- Freeze drying
- High gradient magnetic separation
- Ion exchange
- Liquid ion exchange
- Steam distillation
- Resin adsorption
- Reverse osmosis
- Sedimentation
- Liquid-liquid extracting of organics
- Steam stripping
- Ultrafiltration
- Zone refining

Chemical

- Calcination and sintering
- Catalysis
- Chlorinolysis
- Electrolysis
- Hydrolysis
- Microwave discharge
- Neutralization
- Oxidation
- Ozonolysis
- Photolysis
- Precipitation
- Reduction

Biological

- Activated sludge
- Aerated lagoon
- Anaerobic digestion
- Composting
- Enzyme treatment
- Trickling filter
- Water stabilization pond

Pretreatment of bulk solids of tars

- Crushing and grinding
- Cryogenics
- Dissolution

Source: U.S. EPA 1977.

Factors That Influence Cleanup Costs

We begin by listing the principal determinants of cleanup costs:

- Initial engineering feasibility study for remedial action;
- Site conditions;
- The nature and quantity of the wastes;
- Disposition and storage of the wastes at the site;
- Interaction of the wastes with the site and with other wastes;
- The type of treatment, haulage, and disposal needed to meet regulatory criteria (e.g., allowable residual contaminant levels); and
- Closure and post-closure requirements.

Based on these determinants, a matrix of cost elements for a typical cleanup can be created. One such matrix is listed in Table 5-3. Most of the cost elements shown in this table can be broken down into their constituent factors, such as raw material costs, skilled labor costs, unskilled labor costs, equipment rentals, insurance, taxes, and permits. To obtain specific data for these cost elements, research focused on the following sources: studies on site feasibility, vendor quotations, contractor bids, actual remedial construction costs, publications describing hazardous waste cleanup projects, and in-house engineering and cost data.

Cleanup Costs by Site-Type

EPA sponsored a 1983 study of 82 hazardous waste site cleanups (Wise and Amman 1983), which examined the cost elements listed in Table 5-3 in more detail. As expected, they found wide variations in cleanup costs. Not only did these costs vary according to the factors mentioned above (waste characteristics, site characteristics, etc.) but also by EPA region. For example, they found that the average cleanup cost per site for Region 1, based on data from seven sites, was

Table 5-3 Factors That Influence Cleanup Costs of a Hazardous Waste Site

	Elements that influence cost									
	Lab & eng. studies	Quantity or size	Waste type	Site features	Onsite treatment	Fence	Removal	Transportation	Disposal*	Other costs
Storage method										
Drums	Y	Y	Y	Y	P	Y	Y	Y	Y	
Tanks										
a. Waste	Y	Y	Y	--	P	Y	Y	Y	Y	
b. Tanks	Y	Y	--	Y	--	--	--	Y	Y	
Lagoons, ponds, and pits										
a. Liquids	Y	Y	Y	Y	P	Y	Y	Y	Y	B,C
b. Sludge	Y	Y	Y	Y	P	--	Y	Y	Y	B,C
Extent of contamination										
Soil	Y	Y	Y	Y	P	Y	Y	Y	Y	C
Buildings	Y	Y	Y	Y	P	Y	--	--	--	
Leachate development	Y	Y	Y	Y	Y	Y	Y	Y	Y	M
Ground water	Y	Y	Y	Y	Y	Y	Y	--	--	M
Municipal wells	Y	Y	Y	Y	Y	Y	--	--	--	M

*Disposal can occur as incineration, offsite treatment, deep-well injection, or landfill.

Y = Needed
P = Possible

Other costs:
B = Backfilling
C = Capping
M = Post-closure monitoring

$6.9 million for capital costs and $0.3 million per year in operating costs. In Region 3, the average cost per site was $5.0 million for capital costs and $0.3 million in annual operating costs.

Table 5-4 lists the average cleanup cost by type of site, based on the 1983 study noted above. Landfills had the highest capital costs, $7.55 million, and the highest annual operating costs, $0.56 million. Lagoons had the lowest capital costs, $2.55 million, as well as the lowest operating costs at $90,000 per year.

For the 80 cases studied, the weighted average capital cost was $5.7 million and the weighted average annual operating cost was $340,000. These weighted average costs can be considered the "typical" cleanup costs of a hazardous waste site. Two points should be kept in mind when evaluating these data. Sites on the EPA National Priority List, on which the above cost study was done, are generally more expensive to clean up than the "average" hazardous waste site. This is offset, however, by the fact that the EPA is adopting more stringent standards (e.g., lower allowable levels of residuals) for cleaning up these "average" sites.

In summary, a company that generates hazardous wastes creates negative externalities (i.e., impacts external to the company). Because hazardous waste-generating companies may be individually and jointly responsible for the cleanup costs of hazardous waste, waste generators shoulder the social costs of generating hazardous wastes. Consequently, the future opportunity costs of generating hazardous waste have risen significantly for generators. Opportunity costs refer to those investments and therefore those positive cash flows that are foregone, because the generators' resources are being devoted to the cleanup of a hazardous waste site. This, in turn, should provide yet another incentive for generators to invest in technologies and processes that reduce waste at the source.

Table 5-4 Average Estimated Cleanup Cost by Type of Site

	Sample size	Average capital cost per site ($ million)	Average annual operating costs ($ million)
Landfill	30	7.55	0.56
Wells	7	4.76	0.49
Industrial dumps	25	4.26	0.13
Chemical plants/ refineries	10	6.58	0.26
Manufacturing plants	4	3.51	0.20
Pure lagoons	4	2.55	0.09
Weighted average	80	5.7	0.34

Source: Wise and Amman 1983.

5.2.3 Liability as an Incentive for Onsite and Offsite Recycling

The more sensitive a corporation is to the potential for future environmental liability, the more likely it is to look for ways to maximize control over the eventual fate of hazardous wastes. Where it is feasible to recycle onsite, that is likely to be a high priority. Where recycling would mean sending the waste offsite, other onsite disposal alternatives including landfilling may be preferred. Under RCRA, owners and operators of TSD facilities must demonstrate financial responsibility (40 CFR 264 Subpart 4). An offsite recycling facility could cause environmental damages resulting in liabilities in excess of the recycler's financial capacity and insurance limits required under RCRA. This may result in the firm's declaring bankruptcy. As a consequence, the generator could potentially be subject to uncertain future liabilities under the court interpretation of CERCLA's strict, joint, and several liability provisions.

Even where care is taken in the selection of an offsite recycler, many companies indicate that, since the generator remains responsible for any waste mishandled by the recycler, the potential liability far outweighs any short-term economic benefit. A lawsuit or third party claim could hold all generators, transporters, and recyclers joint and severally and strictly liable. (Such an attitude could present a special obstacle for those waste exchanges that actually buy and sell wastes, since careful pre-screening of the eventual purchaser/user of the waste is likely to be problematic. It would not, however, necessarily preclude an expansion in the role of active informational waste exchanges, which put the generating and purchasing parties together to arrange any sale.)

If a company that sends its wastes offsite is aware of this problem, it will make every effort to pre-qualify the offsite waste management or recycling firm involved. Pre-qualification involves an examination of the environmental, business, and regulatory aspects of the recycling facility, as well as a review of the recycler's pollution insurance contracts. The fundamental question is how well any disposal or recycling service is equipped to protect the original generator from future liability.

This means analyzing the recycler's risk management and insurance situation, its sales volume, its loss control and loss prevention techniques, its environmental setting and site characteristics, the inherent toxicity or hazard potential of chemicals being used, as well as their transport, fate, and persistence in the environment, and the overall environmental management practices relative to pollution control technology and potential receptors (e.g., population centers or ground-water aquifers).

To some degree, the issue of liability can make offsite recycling preferable to offsite landfilling. Generators who do not have the facility for onsite disposal, treatment, or recovery are forced to consider offsite waste management. Although the options of offsite recycling and offsite land disposal both present risks, the latter alternative may be seen as less risky. Offsite land disposal offers the potential for improper landfill design, and also does not reduce the amount of waste ultimately disposed of in this manner. Offsite recycling, while still presenting the potential for improper management, affords the opportunity for a reduction in the amount of land disposed waste; in some instances, there is the possibility of zero land disposed waste if no reclamation (causing residues that are hazardous) is involved. Familiarity with the offsite recycler again plays a role, as does the amount of waste generated in making this decision. If the waste generated is below the minimum amount required by some recyclers, the generator is forced to accumulate and store it onsite, thus requiring storage permits in many cases. Permitting costs may preclude this as an option, however (see Section 5.5.6 for further discussion of this issue). A critical factor in making liability an issue in the waste management decision is the aggressiveness of the Federal and/or State environmental policies, regulations, and enforcement action plans that affect both corporate officer and corporation liability.

The increasing number of citizen suits and community right-to-know laws will create greater incentive to recycle waste in order to preclude real or perceived liability from the mishandling or mismanagement of hazardous wastes. Wastes sent to a recycler, however, frequently result in residuals that are shipped offsite by the recycler (e.g., organic still bottoms). These residual wastes may remain the responsibility of the generator, however. This means that there are likely to be at least two sites (in addition to transport) where mishandling could occur. Even if the generator has pre-qualified the recycler, uncertainty about (or the additional cost of pre-qualifying) the second user makes such a transaction less attractive. Onsite disposal subject to the direct control of the generator may appear to pose less future risk. For those companies with the resources and in-house expertise, onsite recycling may be a preferred option.

Another aspect of the effect of liability on recycling is its relationship to transporters. A transporter involved in a spill of hazardous wastes faces an equivalent amount of financial liability as that associated with a spill of hazardous materials that are not wastes. The immediate costs of the transporter's insurance (assuming he can obtain it) should be the same. That is, if he is the carrier, he is responsible for the damages caused by spills of either hazardous materials or hazardous wastes. Under the CERCLA statute, however, the transporter may potentially be held liable for damages caused by subsequent releases of hazardous materials that are delivered to facilities for treatment or disposal (Section 107(a)(3) and (4) of CERCLA). Thus, if the company accepting the waste spills the material, or the residues from the reclaimed solvent are deposited in a landfill that contaminates drinking water in the future, the transporter may be held financially responsible, depending on the circumstances and the outcome of the court's decision. Conversely, a transporter may deliver virgin solvent to a company that uses it in its manufacturing process. The company generates a spent solvent that is a hazardous waste under RCRA. The transporter of the raw material would not generally be held liable for damages resulting from the subsequent transport or management of the waste generated from processing the raw material.

Presently, transporters are able to obtain insurance for their own activities. Insurance for future liability caused by others is extremely difficult, if not impossible, to obtain. As a result, transporters of hazardous waste, in order to ensure financial responsibility, may charge larger fees than for transport of hazardous substances that are not delivered for treatment or disposal. The fee charged would be to ensure that the transporter could self-insure.

The effect of this situation is likely to result in a preference for the use of raw or virgin materials in processes, as opposed to materials that may need to be reclaimed prior to use, since the cost of transporting raw materials would be cheaper. Spent materials that could be used directly without prior reclamation may be in the same category as raw materials because of recent changes in EPA's definition of solid wastes (as discussed in further detail in Section 5.5.2 and Appendix F). Under the revised regulations, materials that are used as effective substitutes for virgin materials without reclaiming prior to or during the process are not solid wastes. As a result, these materials are equivalent to raw materials, and do not need to be manifested.

Depending on the nature of the waste to be recycled, therefore, raw materials may be less costly (and thus preferable) to use than waste materials in a manufacturing process. Given a choice between a virgin material and a waste that must be shipped and processed prior to use, a company may prefer to use virgin materials. Liability may thus play a role in this cost barrier associated with transportation.

5.3 Organizational and Attitudinal Aspects

This section addresses the organization and implementation of environmental programs within private companies, summarizes some industry perceptions of the regulation of hazardous waste under RCRA, and touches upon some of the origins of opposition to change within organizations. Information for this section was gathered primarily from sit-down interviews with environmental personnel in the chemical industry; from telephone interviews with environmental personnel in the chemical industry; from telephone interviews with private companies and trade associations; and from a review of industry questionnaires summarized in the materials distributed at the Woods Hole conference (LWVM 1985). Further insights were provided by examination of sources dealing with organizational behavior and corporate environmental expenditure policy.

5.3.1 The Organization of Environmental Programs within Firms

Corporate environmental departments began to appear in the 1970s after the Clean Water and Clean Air Acts had established guidelines for industry effluents and emissions. The concentration of environmental expenditures at that time was in end-of-pipe treatment equipment, which reduced the environmental impairment potential of industrial discharges into air and water. Waste reduction, within the framework of corporate policy, was carried out more from an operating efficiency perspective, however. The aim was to increase product yield and reduce material costs in an effort to improve profits; waste minimization was coincidental. Waste minimization also occurred during the energy crisis of the 1970s when rising oil prices were having an inflationary effect on manufacturing costs. As a result, attention turned toward reuse of fuels and incineration of wastes to extract energy value, which was previously uneconomical to recover.

Corporate waste management policies were redrafted when regulations were developed in 1980 to enforce provisions of the 1976 Resource Conservation and Recovery Act. The hazardous waste manifest tracking system and new waste disposal requirements placed heavier demands on firms' environmental departments. Strategies were revised to address methods of reducing waste generation and of optimizing the treatment or disposal of any waste generated after all obvious waste minimization steps had been taken. These strategies were reinforced in 1984 by: (1) Section 224 of HSWA, which required that all waste manifests and onsite TSD permits be accompanied by a certification of efforts to reduce the volume and/or toxicity of the hazardous waste generated; (2) the land disposal restrictions also contained in HSWA; and (3) the potentially severe liabilities for hazardous waste generators and disposers established under CERCLA. The possibility of being targeted as a "deep pocket" under the court's interpretation of the joint and several liability provisions of CERCLA and the lack of any time limitation on environmental impairment liabilities have contributed to greater waste minimization emphasis within companies.

Many large companies organize their environmental efforts in a manner similar to the structure described in Figure 5-1. A corporate environmental affairs office is located at corporate headquarters and links corporate management to the environmental activities of the operating divisions and individual plants. Environmental directives are issued by corporate management to the environmental affairs office, which develops the environmental program for the company. The elements of the program are transmitted to the operating divisions via instructional memoranda or guidance documents, and the corporate environmental affairs officer typically is charged with program oversight, assistance, and progress review. The actual environmental projects are implemented within the operating divisions by plant-level personnel.

A variation on this approach to environmental tasks is also shown in Figure 5-1. Here, a task force is formed consisting of engineers with environmental and process experience. The task force travels from plant to plant to review production processes and operating procedures, and it recommends improvements in production efficiency and waste minimization to plant and corporate management. Companies using this approach have found it more effective than relying on operating personnel to initiate environmental projects. The approach requires a greater commitment of resources, however.

The environmental responsibilities for smaller companies and businesses are usually handled by an individual, often the owner and/or general manager of the plant, who is primarily concerned with overall plant operations and profit margins. Environmental matters often are not of primary interest. Examples of substantial waste minimization and cost savings can be found among smaller firms, however. Attention is turned toward waste minimization when costs must be cut and/or when regulatory approval or interaction is involved.

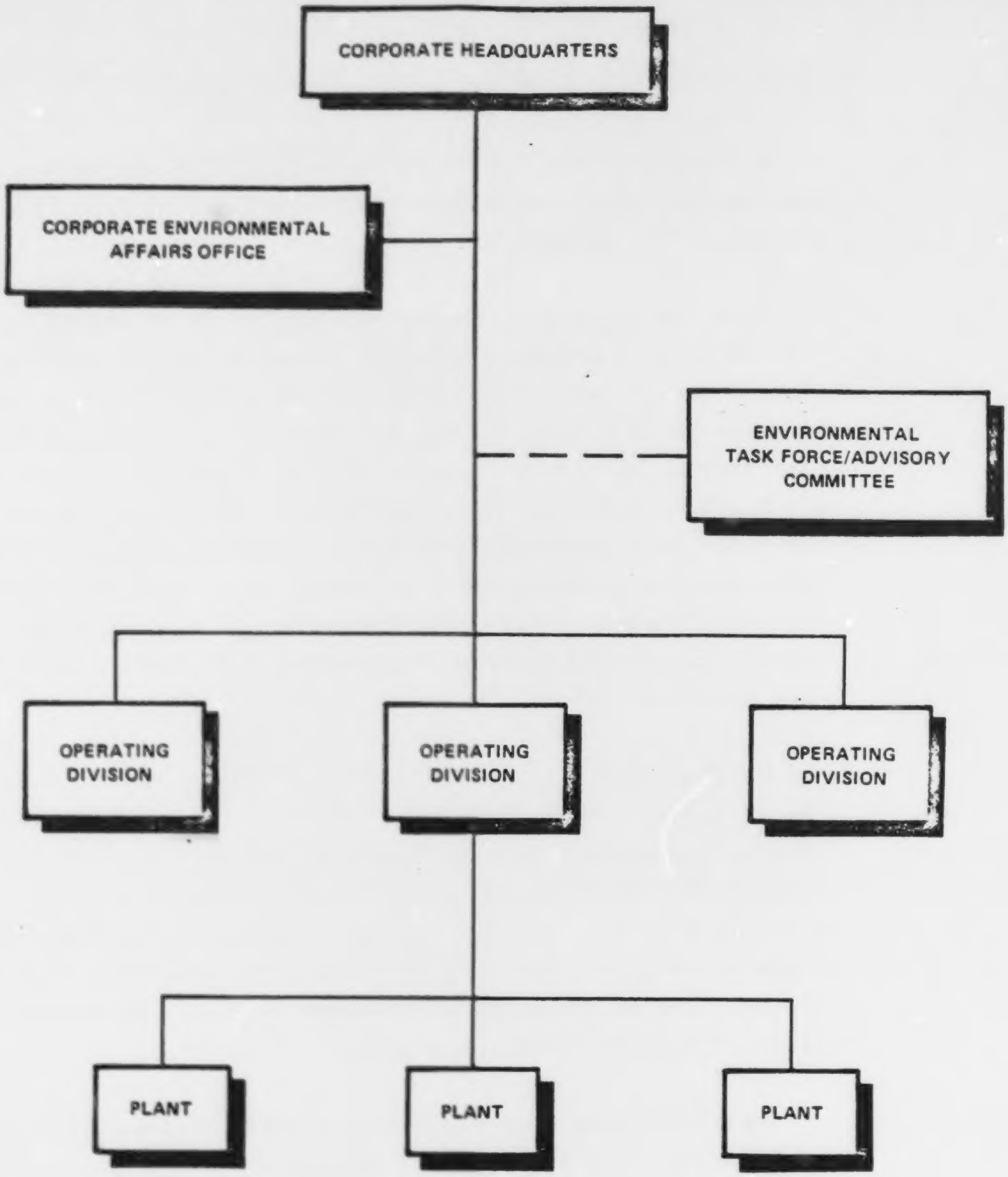
CORPORATE HEADQUARTERS
CORPORATE ENVIRONMENTAL AFFAIRS OFFICE
ENVIRONMENTAL TASK FORCE/ADVISORY COMMITTEE
OPERATING DIVISION
OPERATING DIVISION
OPERATING DIVISION
PLANT
PLANT
PLANT

Figure 5-1 Organizational Structure for a Typical Corporate Environmental Program

5.3.2 Company Policy-Making and Policy Implementation Processes

Most major corporations have a formal environmental policy statement that includes mention of waste minimization or materials conservation. The statements have generally been formulated by corporate management (director level) and endorsed by the chief executives. At some companies, environmental policies went into effect in the early part of this century, while at others policies are much more recent. Environmental policies are updated as necessary to reflect new developments.

Projects are devised by onsite plant personnel with oversight and assistance from the corporate environmental staff. This reflects the site-specific nature of waste minimization and other environmental projects. Prior to implementing waste minimization projects, company personnel will usually: (1) set priorities for waste stream reductions according to the volume, toxicity, cost of treatment/disposal, and waste-to-product ratios of each waste stream; and (2) establish waste minimization goals, technical requirements, and time schedules for each waste stream.

Operating managers are held accountable for waste minimization progress, which is reported to corporate management at regular intervals. To aid in monitoring and tracking waste minimization progress, many companies have constructed computer data bases containing information on waste stream type, RCRA waste code, and volume generated. Waste minimization statistics, along with other environmental data, are sent to corporate management at least once annually. Standard reports to management, which are influenced by waste minimization statistics, include reports on operations improvement plans, product yields, raw materials consumption, and employee suggestion projects.

Problems may arise in larger companies when environmental managers do not communicate or interact effectively with their production-oriented counterparts or those who are responsible for research and development. Engineers involved with project development and process design may not be familiar with the technical and regulatory problems associated with waste disposal or the economic, environmental, and public relations benefits of waste minimization. Moreover, engineers responsible for production operations may not be fully cognizant of the problems associated with hazardous waste handling and disposal and the potential environmental liabilities associated with generated waste streams. If actual costs and waste problems are communicated to these engineers and plant operators, the rationale for applying new waste minimization technology becomes clearer. Effective communication of the corporate waste minimization policy to all operations levels contributes to the implementation of a successful waste minimization program. Furthermore, it is often helpful for a new waste minimization process or method to be promoted by a "champion," a high-ranking individual who is actively committed to waste minimization and who makes efforts to overcome both developmental problems and the general inertia that protects existing, but highly waste-producing, practices.

Some companies have employed education and incentive programs to raise awareness about waste generation. Waste minimization newsletters, cash awards, and certificates are used to increase employee awareness and motivation. Trade associations sponsor seminars and workshops on waste minimization in which member firms take part.

In smaller firms, pollution control policy making and implementation are carried out on a case-by-case (e.g., regulation-by-regulation) basis. Long-range environmental planning is uncommon. Small businesses regularly implement policy by hiring consultants in order to learn what is required and how to achieve waste minimization. The consultant's advice is acted upon by the owner/plant manager, who usually commits operating personnel to these activities on a part-time basis.

Some small operations concentrate on a common sense/good housekeeping policy approach. This is done in industries where the production technology is relatively established and readily available, e.g., in paint manufacturing. Trade associations and waste exchanges are valuable waste minimization resources for small businesses in particular.

5.3.3 Industry Perception of RCRA

Although government regulation of industry is not new, extensive environmental regulation is a fairly recent development. The 1976 Resource Conservation and Recovery Act (RCRA) and the subsequent 1984 Hazardous and Solid Waste Amendments (HSWA) set down nationwide requirements for industry. Reaction to the legislation among private companies has been mixed. Congress is viewed by some in industry as having mandated strict compliance schedules without considering EPA's capability to implement regulatory programs by the desired dates. The result has been uncertainty over deadlines, changing requirements, and complex regulations, all of which create coordination difficulties for company planning. An expression often heard is that companies must plan around a "moving target."

Furthermore, some companies perceive that RCRA is implemented inconsistently throughout the United States. RCRA programs are viewed as being inconsistent or lacking uniformity among EPA regions and among the States that administer RCRA programs, causing industry to be subjected to an endless process of permitting in order to comply with both State and Federal regulations. Industry is concerned that States administering RCRA programs cannot always be objective and nonpolitical in their decision-making because of local pressures against the permitting and siting of TSD facilities.

Complicated permit application and information submittal procedures mandated under RCRA and HSWA are viewed as making "good faith" compliance difficult and costly. Because of the high cost and significant amount of time associated with obtaining RCRA permits, many companies are reluctant to get involved with hazardous waste treatment, recycling, and storage activities. As disincentives to securing RCRA permits, companies cite permit application costs up to $250,000 and months spent interacting with EPA officials. In addition to these disincentives, generators who engage in onsite volume/toxicity reduction efforts are often confronted, when applying for RCRA permits, with the following:

- Possible exposure of proprietary technology;
- Possible adverse media coverage; and
- Continuing EPA compliance activities.

Further barriers to obtaining RCRA permits have been cited by industry. One barrier, which stems from HSWA, focuses on RCRA Section 3004 (u), a provision requiring that, as a condition of a RCRA permit, prior environmental releases of hazardous wastes of constituents be corrected or cleaned up and that financial responsibility be assured for completing all corrective actions. This "corrective action" provision is viewed by industry to be a barrier to any company's attempt to establish a waste treatment, disposal, or recycling business in an industrial area.

Some companies believe that the recent revisions to the solid waste definition in EPA's regulations under RCRA provide other disincentives to waste minimization, most notably in the waste recycling area. To support this contention, industry has provided specific examples of how EPA's January 4, 1985, definition of solid waste tends to restrict the recycling of certain types of wastes. This is described in further detail in Section 5.5.2 as well as in Appendix F.

Notwithstanding the uncertainties and possible misinterpretations of the definition of solid waste, the increased number of wastes requiring manifests under the regulation relate to the concern expressed over the difficulty of delisting. In particular, a waste sent to an offsite recycler would yield a residual for which - if not delisted - the original generator of the recycled waste could bear liability. Since some of these wastes were previously exempted from the manifesting requirement, the number of waste streams for which delisting petitions may be filed may increase.

The following is a list of other RCRA-related issues viewed by industry as disincentives to hazardous waste minimization programs:

- Permitting requirements - Source reduction sometimes requires the installation of new machinery that can, under RCRA, be considered "treatment." This in turn could require a generator to obtain a permit as a treatment, storage, and disposal facility (TSDF). This permitting process can be expensive and generally requires two years to complete. In addition, HSWA Sections 3004 (u) and (v) require permitted facilities to conduct corrective action to clean up any contamination that could have previously migrated from their facility.

- Storage requirement - The requirement that a permit must be obtained to store hazardous waste for longer than 90 days is a disincentive to recycling. For some batch chemical operations, wastes must be stored longer than 90 days in order to accumulate enough reactant for the batch process.
- Mixture rule - Companies have questioned the RCRA hazardous waste mixture rule, which may allow small amounts of hazardous wastes to render as hazardous a large nonhazardous waste volume when the two components are mixed together. From an industry viewpoint, there is no justification for defining the entire waste volume as hazardous when the hazardous constituents are fixated within the waste and the leaching potential is minimized.
- Process recertification - Firms may not be motivated to change manufacturing processes to achieve waste minimization, if recertification of the new process is necessary to comply with TSCA and Food and Drug Administration (FDA) regulations. Modifying permits under TSCA or FDA regulations is costly to industry in terms of time requirements. Companies indicated that it typically takes from six months to one year to secure a permit modification.

Companies have noted that HSWA did offer some incentives to waste minimization. As a result of having to certify waste volume and toxicity minimization, some companies have developed data bases and records on waste production processes, waste types, waste volumes, treatment and disposal methods, and costs. Several companies are currently maintaining computerized hazardous waste generation data bases, and they feel that Congressional action (the inclusion of Section 224 to the 1984 amendments) has justified their investment in the data bases.

5.3.4 Origins of Opposition to Change

Waste minimization as an operating practice is a relatively new concept for industry; as noted above, past reductions in waste generation were incidental to the realization of other goals, namely increased product yield and energy recovery. The goal of reducing the waste generated by existing production processes poses a new set of challenges to industry personnel. They may be reluctant to confront these challenges in part because of the habits and attitudes developed through experience with existing production processes and waste management practices.

The effect of habit on industrial design and management practices is the continuation of old designs or of existing management practices. There is a tendency to preserve designs and practices that may generate relatively large waste volumes but which have worked well to the present, because they provide ready solutions to the usual set of production problems. This tendency is more pronounced in operations where waste generation and/or raw materials costs are minor in relation to the value of the final product, or are at least perceived to be tolerable. Familiarity with production techniques also gives rise to operational efficiencies such as lower time and personnel requirements. Management may, therefore, be satisfied with production operations as they stand, even if large quantities of waste are generated (the "If it isn't broken, don't fix it" outlook). This inhibits the development of initiative among managers to take waste minimization measures.

Coupled with this lack of initiative, familiarity with existing operations and unfamiliarity with innovative technologies or approaches create a tendency to reject changes in existing techniques and to develop attitudes that oppose change. For example, there is the "can't be done" attitude, where a concept is dismissed before it is developed to the point where it can be fully understood. Management "policy" may be at the root of the rejection, or it may be felt that the idea requires too much time or trouble to investigate. A similar idea may have been tried under other circumstances and failed; hence, a new idea is dismissed by association without a deeper, situation-specific analysis. Whatever its origins, the "can't be done" attitude can present a powerful barrier to change, and previously has been identified as such by practitioners of value engineering, an engineering activity performed to reduce cost without sacrificing functionality of design (Zimmerman and Hart 1982).

Opposition to possible waste minimization measures may arise out of a fear of product quality detriment. This is a common reason for not reusing recovered feedstocks, as they are typically not up to the specification of the original feedstocks. Recycled feedstocks may be rejected out-of-hand for similar reasons. In general, firms are reluctant to pursue waste minimization if they fear that customer satisfaction may be jeopardized. Also, some firms may not have the latitude to alter production techniques if the mode of production is contractually specific.

Fear of product quality detriment is only one of several factors that may dissuade individuals from pursuing new waste minimization methods. Process modifications may involve protracted production downtime, which impedes the fulfillment of production goals or contractual obligations. In this context, shutting down the process is a relatively expensive endeavor. Also, because waste minimization projects compete with other projects for funding, they may receive lower priority, particularly if they involve innovative technologies. Greater investment risk is perceived, especially by smaller firms, for technologies whose commercial feasibility has not already been demonstrated by application in similar production operations. The rate at which the project's cash flows are discounted would then be higher to reflect the higher risk, and the project would be less attractive.

Even in the absence of countervailing attitudes within management, waste minimization may not occur if management views waste minimization (and environmental measures in general) as a service function of low priority in the production-oriented mission of the firm. This can result in a lack of detailed information on waste generation as a component of manufacturing cost. The problems of generating waste cannot be addressed until waste generation costs are quantified in such a manner as to call attention to their significance. Previously, waste disposal as a "cost of doing business" did not vary by much from year to year. The recent rise in disposal costs has had an inflationary effect on overall manufacturing costs, causing managers in some companies to track the cost increases and to take action to offset them.

A related aspect is the availability of needed information. When the costs of waste generation are identified and made known to management, quick, decisive action is often taken. The key problem in such situations is not the lack of managerial commitment to solve the problem; rather, it is a lack of initiative or commitment to recognize and formulate a problem to be solved.

5.4 Consumer Attitudes and Public Relations Issues

As discussed in Section 5.3, one deterrent to initiating waste minimization practices is the risk that a change in the manufacturing process necessary to achieve waste minimization may affect the quality of the final product. Also, altering the specifications of the final product to accommodate the use of less waste-producing raw ingredients may present problems of customer acceptance of the change in the final product. From the standpoint of the manufacturer, product change or substitution may not be a viable waste minimization option, since product quality and specifications are established by consumer and market demand.

Unnecessarily tight product standards can contribute to increased waste generation. For products already favorably accepted by the consumer, however, resistance to change in the quality of the product is likely. This option might be more effective if a program were begun that would educate the consumer on the environmental benefits of supporting lower waste-producing products. When the changes affect consumers directly, they are likely to respond to such programs. For example, the recent educational campaigns encouraging the reduction of sugar and cholesterol in the diet have resulted in consumer demand for foods that are low in sugar and cholesterol. Because of this demand, food manufacturers can target certain products directly toward these consumers, since they are concerned about their health but not necessarily about the process the manufacturer must use to produce such food products.

There is a limit to the response one might expect from consumers for products that have indirect effects, however. Although public education programs dealing with the environmental benefits of certain products may motivate their purchasing decisions, overall product quality and costs may weigh more heavily in their selections. In particular, if the purchase requires a substantial financial commitment, a consumer is less likely to decide to buy a product that would yield only an indirect effect. For example, a consumer is unlikely to purchase a particular computer simply because the computer firm uses waste minimization techniques in the manufacture of its printed circuit boards. The consumer's decision to purchase the computer will, instead, be based on the quality of the product and the price. (In this instance, the quality of the product is not likely to be affected by the waste minimization practice; the decision factors would then be the overall relative quality of the computer and the relative price.)

The degree to which consumers may base their purchasing decisions on companies' environmental practices most likely would be dictated by how much such practices would either (1) affect them directly or (2) run counter to how they feel companies should behave. At the local level, this type of public behavior has manifested itself in the "Not in My Backyard" reaction toward the siting of hazardous waste facilities. Reaction toward existing companies' pollution control practices, however, has not been expressed to the same degree as that toward the siting of waste facilities. Boycotting of products has been less apparent than the objection of people to the siting of hazardous waste facilities in their community.

Reaction to a company's production practices generally will remain confined to the immediate community affected by the plant; a change in consumer demand because of a plant's environmental practices is less likely. In this regard, public relations rather than consumer demand determines the reaction. An example of this type of public relations and public pressure is reflected in situations such as that in the "Silicon Valley" area of California. Over the last few years, the residents of this area have become concerned about evidence of ground-water contamination. Coupled with this was the discovery of elevated incidents of birth defects in the area. Investigations revealed that the contamination was linked to the electronic and semiconductor manufacturers' storage of waste chemicals below ground. Public concern and the resulting negative publicity have caused the electronic firms to undertake investigations and corrective actions.

As a matter of policy, some companies undertake waste minimization and other environmental programs on their own without public pressure. One example of such a program is 3M's Pollution Prevention Pays (3P) program that rewards employees for suggesting innovative cost-saving solutions to environmental problems. The size of the company appears to be a key factor in determining the success of such programs. As discussed in Section 5.1, economies of scale are often a principal factor in a firm's decision to invest in technology. The public image or public relations aspect is also important. Companies that establish good environmental reputations are likely to have better relationships with environmental agencies and are better accepted by the communities in which they are located.

In summary, consumer attitudes may play a role in affecting a company's production process: (1) if the consumer is more aware of the environmental effect produced by the product's manufacture and he/she has a desire to improve the environment; (2) if the consumer is willing to accept changes in product quality; and (3) if the consumer is willing to give up the opportunity to purchase a product that may be cheaper and/or superior in quality. The third option is more likely to occur for products not requiring a substantial financial investment; that is, environmental concerns are more likely to motivate a consumer to try a different paint, but not a different computer. A plant's practices that affect a neighboring community may be influenced at the local level by public relations issues. Public relations may also play a role with respect to a company's reputation. Companies that actively seek environmental solutions may benefit from being perceived as conscientious by both the community and the agencies that regulate them. For both consumer attitudes and public relations aspects to influence waste minimization, education and informational programs appear key ingredients for the development of such changes in attitude.

5.5 Regulatory Aspects

The requirements imposed by RCRA and other regulations may both inhibit and promote waste minimization practices or may be perceived by the regulated community to do so. This may be particularly true of the class of generators who once were exempt from regulation because they generated less than 1,000 kg/month of hazardous waste. With the lowering of the exemption limit to 100 kg/month, a new segment of the service and industrial community is subject to regulation, a segment that must consider perhaps for the first time the various alternatives available for waste management.

At the same time, some regulations may provide incentives to explore waste minimization options, since waste management alternatives may be limited. With a limitation of choices, the economics of waste minimization may then become redefined and what was once marginal may now appear attractive. For example, as EPA implements restrictions or treatment standards for the land disposal of various wastes, companies will necessarily give more consideration to alternatives to land disposal.

This section explores some of the regulatory issues under RCRA and their effect on industry with respect to whether waste minimization is promoted or inhibited. Although the section discusses the effect of RCRA only, it should be noted that the effluent limitations guidelines and standards established under the Clean Water Act also result in source reductions of waste. The RCRA regulations that directly affect hazardous waste minimization, however, are the primary focus for this section.

5.5.1 Waste Minimization Certifications

The regulations that most directly affect waste minimization activities are those resulting from HSWA. In response to these amendments, EPA has revised its Uniform Hazardous Waste Manifest Form (EPA Form 8700-22) so that it contains a certification by generators regarding their efforts to minimize the amount and toxicity of wastes generated. The certification statement now appears as Item 16 on the manifest form.

In addition to the manifest certification requirement, generators are now required to submit a report, at least once every two years, describing their efforts to minimize waste generation. The current requirement for submission of a biennial report has been amended to include (1) a description of the efforts undertaken during the year to reduce the volume and toxicity of waste actually achieved during the year, and (2) the changes in volume and toxicity achieved in a given year compared with previous years. The comparison in item 2 is to be made with respect to previous years "to the extent such information is available for years prior to 1984" [40 CFR 262.41(a)(6) and (7)].

Finally, TSD permits issued on or after September 1, 1985, must contain a condition that the permittee certify annually that a waste minimization program is in place. The program must "reduce the volume and toxicity of hazardous waste that he generates to the degree determined by the permittee to be economically practicable; and the proposed method of treatment, storage, or disposal is that practicable method currently available to the permittee which minimizes the present and future threat to human health and the environment" [40 CFR 264.73(b)(9)].

EPA's concerns will be limited to permittees complying with the certification portion of these regulations. EPA does not have the enforcement authority to ascertain whether such programs are in place or whether they qualify as waste minimization. The legislative history of these requirements states that the language does not authorize EPA to interfere with or to intrude into the production process by requiring standards for waste minimization. Determinations of "economically practicable" and "practicable method currently available" are to be made by the generator, not EPA (50 FR 28734).

Even though EPA has stated that it will not actively enforce standards or guidelines for waste minimization (50 FR 28734), the certification program is likely to make generators more aware of waste minimization, since the act of certifying may by itself act as an incentive for generators to make this effort. It is also likely that some generators will undertake programs that involve some degree of innovation. Because of this, the program may have the effect of making some waste minimization processes more widespread. Waste minimization practices that involve process modifications or product substitutions, however, may be regarded as proprietary. In such instances, that information would not be made available to others.

Since EPA's involvement in providing guidance is limited, companies may seek to do only a minimum in order to certify that they have instituted a waste minimization program. On the other hand, EPA has officially responded to inquiries as to whether particular practices may qualify as waste minimization. Specifically, EPA has prepared responses in which it affirms that participation in waste exchange programs and recycling in general are considered to qualify as waste minimization practices (see Appendix G for EPA's correspondence).

Therefore, the regulations may serve as an incentive to companies that offer services that minimize waste (such as recyclers, manufacturers, or vendors of waste treatment equipment or services) to obtain this recognition. Such recognition could be of use to companies in marketing their services to generators. For example, offsite recycling firms can claim to offer not only a means of waste management, but also a means to help generators certify that they have instituted a waste minimization program. The same potential may exist for marketers of a technology or for firms that offer environmental auditing services.

In addition, the regulations may result in some generators' instituting such practices themselves, without going to outside vendors. Thus, there may be an increase in internal environmental auditing departments to assess the degree to which waste minimization practices may be instituted.

5.5.2 EPA's Definition of Solid Waste

EPA published a revised version of the definition of solid waste in the January 4, 1985, Federal Register. The definition was designed to close the "loopholes" that existed in the RCRA regulations regarding recycling. Although "sham" recycling has always been illegal, the regulations prior to the January 4, 1985, revision allowed characteristic hazardous wastes and commercial chemical products (listed in 40 CFR 261.33) to remain unregulated provided that they were being "beneficially used or re-used or legitimately recycled or reclaimed." Thus, generators did not need to manifest the exempted wastes that were being recycled. There was no regulatory mechanism for ensuring that the exempted wastes were actually being legitimately recycled.

The revised definition introduces new tests by which a substance may be deemed to be (1) a solid waste and (2) legitimately recycled. For materials being recycled, the revision asserts that RCRA jurisdiction is determined by what the material is and how it is being recycled, unlike the previous version that provided an exemption for certain wastes regardless of the method of recycling. Because of its complexity, this section presents the main provisions of the definitions and their potential effects on industry. A detailed explanation of the definition of solid waste is provided in Appendix F.

The central concept in the definition of solid waste is that of "discarding" or throwing something away. If a material is abandoned, it is disposed of, and therefore a solid waste; if it is not abandoned, it is not a solid waste. The definition expands the concept of abandonment to include (1) storing or treating the material if the storing or treating occurs prior to its being abandoned, or (2) certain types of recycling activities. The definition states that four types of recycling activities are within EPA's jurisdiction:

- Use constituting disposal;
- Burning waste or waste fuels for energy recovery or using wastes to produce a fuel;
- Reclamation; and
- Speculative accumulation.

These four categories of recycling activities are further divided according to the type of material involved: spent materials, sludges (listed or characteristic), byproducts (listed or characteristic), commercial chemical products, or scrap metal. Table 5-5 provides a summary of which materials are solid wastes when handled in the respective activity areas.

Wastes that are recycled by being used directly are not defined as solid wastes if reclamation of the material does not occur prior to - or as a condition of - its being used. The definition specifies three situations in which the direct use of the waste would exclude it from the solid waste definition:

- The material is used as an ingredient in an industrial process to make a product.
- It is used as an effective substitute for commercial products.
- It is returned to the process from which it was generated, to be used as a substitute for raw material feedstocks.

For each of the above situations, reclamation must not occur prior to or during its use.

An important concept of the definition is that qualification of a material as a solid waste does not automatically render the activity associated with the material subject to full RCRA regulation. A solid waste material would be regulated only if (1) the material is a hazardous waste and (2) the activity involving the material is subject to the RCRA hazardous waste management standards. For example, although some of the wastes recycled onsite may qualify as solid wastes under the definition, the actual recycling activity is not regulated under RCRA. If the waste is stored onsite for more than 90 days prior to recycling, or if it is stored for any length of time in a surface impoundment or waste pile prior to recycling onsite, then a TSDF permit would be needed for the storage of such waste. In such instances, the recycling activity itself still would not be regulated.

Table 5-5 Waste Materials Defined as Solid Wastes under the Revised Definition

Waste materials	Activities			
	Use constituting disposal	Energy recovery and fuel	Reclamation	Speculative accumulation
Spent materials	•	•	•	•
Sludges (listed in 40 CFR 261.31 or 262.32)	•	•	•	•
Sludges exhibiting a characteristic	•	•	--	•
Byproducts (listed in 40 CFR 261.31/32)	•	•	•	•
Byproducts exhibiting a characteristic	•	•	--	•
Commercial chemical products (listed in 40 CFR 261.33)	•	•	--	--
Scrap metal	•	•	•	•

• Indicates material is defined as solid waste.

The requirements that do apply for solid and hazardous wastes are summarized below:

- Notification procedures (recordkeeping) for hazardous wastes generated that qualify as solid wastes regardless of whether they are recycled on or offsite.
- Manifesting for hazardous wastes qualifying as solid wastes under the definition and that are shipped offsite.
- TSDF permits for storage of hazardous wastes qualifying as solid wastes under the definition if (1) stored by the generator for more than 90 days, or stored for any amount of time in waste piles or surface impoundments, or (2) stored by the firm receiving the material for any amount of time.
- TSDF permits for the treatment of hazardous wastes qualifying as solid wastes under the definition.

There is some confusion over the last item above regarding treatment. A reading of the definition of "treatment" (40 CFR 260.10) shows that reclamation qualifies as treatment. Since treatment activities require permits under the RCRA regulations, one may also conclude that any reclamation of a hazardous waste would require a TSD permit. Although reclamation is indeed a subset of treatment, actual reclamation activities are currently not subject to regulation according to 40 CFR 261.6(c)(1). The confusion arises because the definition of "treatment" does not cross-reference this provision.

Because of this confusing aspect of the regulations, there have been some misunderstandings by industry of what is required and what is not. Some companies believe that any type of reclamation activity (onsite or offsite) requires a permit. These companies may thus perceive the regulations to be more restrictive than they actually are. Discussions with State personnel indicate also that some State environmental agencies are making the same misinterpretations (Kerr 1985b). This compounds the confusion by reinforcing the mistaken ideas through the States' versions of the definition and through their enforcement policies. Thus, a State that believes EPA's regulations require TSD permits for reclamation activities may write and enforce its regulations that way (Kerr 1985b).

Although the reclamation activity itself may not be regulated, storage prior to reclamation does require a permit, as mentioned in the third item above. A generator may store his or her waste onsite for up to 90 days, and would not need a permit. Once the waste leaves the generator's site, however, storage of the waste for any amount of time by the receiver requires a TSD permit. Thus, a company storing waste prior to reclamation would need to obtain a TSD permit. This could result in the non-acceptance by some companies of the newly defined solid wastes for reclamation, since previously they did not need to obtain permits.

Besides the above issues, other difficulties lie in increased requirements resulting from the definition that could result in disputes with EPA. One key aspect of the regulations is that generators will now have to manifest some wastes shipped offsite that, under the previous set of regulations, were exempt from such requirements. For example, a spent material (e.g., a spent solvent) that is both a hazardous waste and that is reclaimed prior to being recycled is defined as a solid waste. If the generator were to ship the spent material offsite to be reclaimed, a manifest would be required.

The manifest, in effect, places the generator's name on the waste - a factor that may cause reluctance to ship wastes offsite to be recycled because of future liability, as discussed in Section 5.2. To generators who previously did not have to manifest wastes when shipping to reclaimers, this is perceived as a constraint to recycling, since it is not clear to what extent they may be liable for any future accident or leak. Members of the regulated community have provided specific examples of how this aspect of the regulation may restrict recycling. In one case, for example, the spent catalyst from a chemical process was not returned to the catalyst manufacturer for regeneration because of the RCRA manifests required.

One advantage of this situation is that there is an increased need for the generator to know of the reliability of the recycler to which the waste is shipped. Thus, the definition may achieve a decrease in the number of "sham" recycling operations, if generators take extra care in finding out more about the company doing the recycling. Smaller companies, however, may not be able to assess the adequacy or reliability of recyclers. Larger companies, such as IBM for example, conduct audits of the companies to which they send wastes for recycling. A small company may not have the expertise available to make such an assessment.

Although the new definition may be needed to prevent abuse of recycling operations, it may be seen by some companies as discouraging recycling and resource recovery efforts. The definition at this time contains no mechanism for consideration of equivalent uses of waste materials. In this regard, the definition may carry with it some of the inequities and biases that may be inherent in the RCRA statute itself. For example, Section 3014(a) of RCRA states that any regulations governing the recycling of used oil "do not discourage the recovery or recycling of used oil consistent with the protection of human health and the environment." As a consequence of this language, regulations relating to the use of used oil as a fuel do not require "full" compliance with the manifesting requirements of RCRA (50 FR 1704 and 50 FR 49196).

No such privileges are granted at this time toward other recycled substances. Products and raw materials (as opposed to waste products and spent materials) that may be as, or more hazardous than, comparable waste streams are not required to obtain the same degree of permitting, tracking, review, and regulation as the waste streams. Storage of virgin trichloroethane, for example, does not require a TSD permit, but storage of spent trichloroethane by a generator for more than 90 days does need such a permit, even if it is to be sent to a solvent recovery facility for reclamation.

On the other hand, byproducts that are used directly in other processes without additional reclamation are excluded from the definition of solid wastes. Problems, however, center around what is considered to be reclamation. As an example, placement of a liquid in a tank for settling may result in a liquid free from impurities and amenable for reuse. Yet there is some question as to whether the settling is a "treatment" step (subject to regulation), or a "reclamation" step (which is not regulated). Again, some of the confusion could be attributed to the definition of "treatment" itself. Other problems include the fact that the ultimate end use of the product in which the waste material is introduced determines whether it falls under the solid waste definition. For example, a waste used directly as an ingredient or feedstock in a process is not a solid waste, unless the product in which it is introduced is ultimately placed on the land or burned. Thus, wastes that are introduced as ingredients for fertilizer would be solid wastes, and shipping such wastes offsite to the fertilizer company would require a manifest. As a result, the regulated community may be more concerned with escaping regulation even when the opportunity exists to recycle.

In summary, the definition contains both constraints and incentives to recycling. It may be perceived mostly as a constraining mechanism, which, in tandem with other aspects such as liability, siting, and permitting, may contribute to a general negative attitude toward consideration of certain recycling practices.

5.5.3 Land Disposal Restrictions

HSWA focus on the restrictions on land disposal of hazardous waste by imposing bans and limitations on the placement of bulk or noncontainerized hazardous (and eventually nonhazardous) liquids in landfills. The amendments also add new technical requirements for land disposal facilities such as requirements for double liners, leachate collection systems, and other corrective actions.

HSWA allow EPA to place further restrictions on specific wastes not only from landfilling, but also placement in surface impoundments, waste piles, injection wells, land treatment facilities, salt dome formations, salt bed formations, or underground mines or caves. The wastes subject to these restrictions are (1) all solvent- and dioxin-containing hazardous wastes; (2) liquid forms of hazardous wastes that contain certain metals, free cyanides, or PCBs at specified concentrations as well as acid liquid wastes and any hazardous wastes that contain halogenated organics at specified concentrations (the California List); and (3) all remaining listed hazardous wastes, with high volume/high hazard wastes considered first and low volume/lower hazard wastes considered last.

With the exception of landfilling liquid hazardous wastes, EPA is responsible for establishing exceptions to the prohibitions on the other land disposal methods for the wastes mentioned above. The exceptions are to be in the form of treatment standards (Section 3004(m) of RCRA as amended by HSWA). A standard may be a constituent level or a method, either of which reduces the toxicity of the waste or its likelihood to migrate. The result is the protection of human health and the environment (RCRA, Section 3004(m)(1)). As shown in Table 5-6, the legislation sets forth a series of deadlines under which EPA must establish treatment standards for these hazardous wastes. If EPA fails to make a determination on restricting or establishing a treatment standard for any of the wastes by the respective deadline, that waste is automatically banned from land disposal. This automatic banning mechanism is termed the "hammer provision" of HSWA. For the solvent- and dioxin-containing hazardous wastes and the "California List" wastes, EPA must also make a determination regarding their disposal by underground injection into deep injection wells. EPA has until August 8, 1988, to make such determinations. Thus, unless EPA makes a determination beforehand, these wastes may be disposed via this method until that date.

After the effective date of a prohibition, wastes may be land disposed (except for landfilling of liquid wastes) if they comply with the treatment standard. For some wastes, there may be no standard or no form of land disposal that can satisfy that requirement. In such cases, the waste would be banned from land disposal. For wastes that are banned or for which treatment levels are established, EPA may allow a two-year extension for land disposal if it is demonstrated that treatment technology and/or capacity to accommodate such wastes are limited. After the two-year time period, the ban and/or treatment standard are in effect. Presumably, Congress, in allowing such extensions, expects that advances in treatment technology and/or increases in treatment capacity would occur during the two-year period to accommodate such wastes after the extension has expired.

Table 5-6 Timetable of Land Disposal Restrictions

Deadline	Action
November 8, 1986	Treatment standards for land disposal of dioxin- and solvent-containing hazardous wastes (except for underground injection into deep injection wells).
July 8, 1987	Treatment standards for land disposal of California List wastes (except for underground injection into deep injection wells).
August 8, 1988	Treatment standards for land disposal of at least one-third of all listed hazardous wastes.
August 8, 1988	Treatment standards for underground injection of solvent- and dioxin-containing hazardous wastes, and California List wastes into deep injection wells.
June 8, 1989	Treatment standards for at least two-thirds of all listed hazardous wastes.
May 8, 1990	Treatment standards for all listed hazardous wastes and all wastes identified as hazardous based on a characteristic.

HSWA also allow EPA to approve, for a specific restricted waste, a site-specific petition. The petition must demonstrate that there will be no migration from the disposal unit for as long as the waste remains hazardous.

In the May 31, 1985 Federal Register, EPA proposed a schedule for land disposal restrictions (50 FR 23250). As required by RCRA Section 3004(g), the schedule divided the waste streams listed in 40 CFR 261 into thirds based on intrinsic hazard and volume disposed, with highly toxic and high volume wastes scheduled first. EPA proposed that each listed waste stream be ranked according to the product of its toxicity and volume scores. The toxicity score represents "the inherent toxicological properties of hazardous constituents in the waste." The volume score represents "the volume of the hazardous waste disposed of in or on the land" [Environ Corp. 1985]. Recently, EPA has proposed regulations (January 14, 1986) in the Federal Register that establish procedures (1) to set treatment standards for hazardous wastes; (2) to grant nationwide variances from statutory effective dates; (3) to grant extensions of effective dates on a case-by-case basis; and (4) for EPA to evaluate petitions that "continued land disposal is protective of human health and the environment" (51 FR 1602). Also, EPA has proposed treatment standards and effective dates for certain solvent- and dioxin-containing hazardous wastes. The regulations would prohibit land disposal of such wastes unless treatment standards are achieved. The treatment standards would not apply to the disposal of these hazardous wastes in underground injection wells (proposed 40 CFR 268.1(c), at 51 FR 1760). Finally, EPA has proposed a two-year extension (until November 8, 1988) for the prohibition of disposal of these wastes in landfills or surface impoundments, provided such facilities meet the minimum technological requirements of proposed 40 CFR 268.4(i)(2) (proposed 40 CFR 268.31(b) at 51 FR 1764). Table 5-7 presents a list of the wastes for which EPA has proposed these restrictions.

The overall effect of the land bans on waste minimization is not definite at this time; however, the prohibitions limit waste management alternatives by eliminating, or greatly restricting, one of the most inexpensive, and therefore most popular, management methods: land disposal. Generators of hazardous waste are forced to examine other waste management alternatives, recycling and source reduction

Table 5-7 Solvent- and Dioxin-Containing Hazardous Wastes for Which Land Disposal Restrictions Were Proposed by EPA[a]

Waste code	Description
F001	The following spent halogenated solvents used in degreasing: tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, carbon tetrachloride, and chlorinated fluorocarbons; all spent solvent mixtures/blends used in degreasing containing, before use, a total of 10 percent or more (by volume) of one or more of the above halogenated solvents or those solvents listed in F002, F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.
F002	The following spent halogenated solvents, tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, chlorobenzene, 1,1,2-trichloro-1,2,2-trifluoroethane, ortho-dichlorobenzene, and trichlorofluoromethane; all spent solvent mixture/blends containing, before use, a total of 10 percent or more (by volume) of one or more of the above halogenated solvents or those solvents listed in F001, F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.
F003	The following spent nonhalogenated solvents; xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, methyl isobutyl ketone, n-butyl alcohol, cyclohexanone, and methanol; all spent solvent mixtures/blends containing solely the above spent nonhalogenated solvents; and all spent solvent mixtures/blends containing, before use, one or more of the above nonhalogenated solvents, and a total of 10 percent or more (by volume) of one or more of those solvents listed in F001, F002, F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.

Table 5-7 (continued)

Waste code	Description
F004	The following spent nonhalogenated solvents: cresols and cresylic acid and nitrobenzene; all spent solvent mixtures/blends containing, before use, a total of 10 percent or more (by volume) of one or more of the above nonhalogenated solvents or those solvents listed in F001, F002, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.
F005	The following spent nonhalogenated solvents: toluene, methyl ethyl ketone, carbon disulfide, isobutanol, and pyridine; all spent solvent mixtures/blends containing, before use, a total of 10 percent or more (by volume) of one or more of the above nonhalogenated solvents or those solvents listed in F001, F002, and F004; and still bottoms from the recovery of these spent solvents and solvent mixtures.
F020	Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production and manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tri-, or tetrachlorophenol, or of intermediates used to produce their pesticide derivatives.. (This listing does not include wastes from the production of hexachlorophene from highly purified 2,4,5-trichlorophenol.)
F021	Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production or manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of pentachlorophenol, or of intermediates used to produce its derivatives.
F022	Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) or tetra-, penta-, or hexachlorobenzenes under alkaline conditions.

Table 5-7 (continued)

Waste code	Description
F023	Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production of materials on equipment previously used for the production or manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tri-, and tetrachlorophenols. (This listing does not include wastes from equipment used only for the production or use of hexachlorophene made from highly purified 2,4,5-trichlorophenol.)
F026	Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production of materials on equipment previously used for the manufacturing use (as a reactant, chemical intermediate, or component in a formulation process) of tetra-, penta-, or hexachlorobenzene under alkaline conditions.
F027	Discarded unused formulations containing tri-, tetra-, or pentachlorophenol, or compounds derived from these chlorophenols. (This listing does not include formulations containing hexachlorophene synthesized from prepurified 2,4,5-trichlorophenol as the sole component.)
P022	Carbon disulfide
U002	Acetone
U031	n-Butyl alcohol
U037	Chlorobenzene
U052	Cresols and cresylic acid
U057	Cyclohexanone
U070	o-Dichlorobenzene

Table 5-7 (continued)

Waste code	Description
U080	Methylene chloride
U112	Ethyl acetate
U117	Ethyl ether
U121	Trichlorofluoromethane
U140	Isobutanol
U154	Methanol
U159	Methyl ethyl ketone
U161	Methyl isobutyl ketone
U169	Nitrobenzene
U196	Pyridine
U210	Tetrachloroethylene
U211	Carbon tetrachloride
U220	Toluene
U226	1,1,1-Trichloroethane
U228	Trichloroethylene
U239	Xylene

[a] January 14, 1986 at 51 FR 1763; 40 CFR 268.30(b).

among them. The phased aspect of this RCRA provision encourages waste minimization by allowing EPA and the regulated community to focus on particular waste streams and potential waste minimization technologies en masse. The program, as proposed in the January 14, 1986 Federal Register, may have the effect, however, of channeling solvent- and dioxin-containing wastes into deep injection wells via underground injection, at least until such activity is prohibited. If the cost of such a practice remains competitive with source reduction or recycling, it is not likely that the program would cause an increase in these practices for solvent-containing hazardous wastes. On the other hand, time constraints may leave insufficient time for research and development and may result in a shortage of treatment and storage capacity. On the whole, however, the increased restrictions are certain to cause some companies to choose source reduction and/or recycling where the economics of such a practice warrants it.

5.5.4 Technological and Other Requirements for New and Existing TSD Facilities

HSWA impose conditions for all TSD facilities through the RCRA permit programs. These provisions apply immediately to facilities in all States, whether or not the State is authorized to administer its own hazardous waste program. Key features of the requirements are summarized below:

- All Treatment, Storage, and Disposal Facilities. In order for owners and operators to obtain a final permit for approved operation, the owners will need to take corrective actions for releases of hazardous waste (or constituents) from any solid waste management unit on the property. This requirement applies regardless of when the waste was placed in the unit, or whether the unit is closed. Owners and operators are also required to provide financial assurance that they can complete the needed corrective action.

- New and Expanded Landfills and Surface Impoundments. All new, replacement, and lateral expansion units of landfills and surface impoundments will require ground-water monitoring and installation of two or more liners with leachate collection above or between liners, as appropriate.

- Landfill and Surface Impoundment Exposure Information. After August 8, 1985, each application for interim-status operation must be accompanied by exposure information. This information must address potential hazardous waste releases in the course of transportation to or from the waste disposal unit. It must also address normal operations and accidents, and the potential pathways, magnitude, and nature of human exposure to such releases.

- Existing Surface Impoundments. For interim-status surface impoundments that were in existence on November 8, 1984, two or more liners with leachate collection between the liners must be installed. Also, the owners and operators must monitor ground water by November 8, 1988.

- Waste Piles. Interim-status waste piles that receive waste into new units or lateral expansion or replacements of existing units on or after May 8, 1985, must meet the standards in 40 CFR Part 264 for liners and leachate collection systems. These standards are more encompassing than those in 40 CFR Part 265 with which such units previously had to comply.

The requirements for new and expanded landfills and new surface impoundments may be waived by EPA as long as the alternative design, operating practices, and location characteristics prove equivalent in the prevention of leachate migration.

As in the case of the land disposal restrictions discussed in the previous section, the technological and other requirements for TSD facilities contribute to the limitation of waste management alternatives. The above requirements are likely to result in an increase in the cost of land disposal. In addition, there may be an increase in closures of land disposal facilities, since some operators/owners may not be able to comply with the new requirements. Costs of landfilling may also increase because of the difficulty of obtaining liability insurance (see Section 5.2.1 for a discussion of this issue). Because owners of land disposal facilities must be able to demonstrate financial responsibility, fees that generators pay for disposing of the waste may be increased to cover such financial assurance (personal communication with C. Ray Hanley, Project Manager, Geysers Project, Pacific Gas and Electric Company, San Francisco, California, January 24, 1986). A decrease in the number of landfills combined with increased costs of land disposal could result in an increase in waste minimization practices. The technological requirements coupled with the land disposal restrictions are likely to cause generators to consider other waste management alternatives, among them source reduction and recycling. An increase in onsite treatment may also be a result; to some extent such onsite treatment may be an integral part of a source reduction strategy.

5.5.5 Siting

Despite the problems with environmental liability insurance discussed in Section 5.2, the potential for increased offsite recycling still exists, given the potential land disposal bans and other factors such as possible increases in virgin materials and costs of treatment and incineration. An increase in offsite recycling may create a need for additional facilities; however, recyclers share the difficulties of other hazardous waste businesses in finding new sites and obtaining timely approval of permits. The siting problem is the familiar one of "not in my backyard." It would seem particularly counterproductive to block construction of recycling and recovery facilities, when the principal alternatives may be more detrimental to the environment and create more potential risk to human health. But those objecting to the siting are unlikely to reject that argument in the abstract -- only in the concrete as it relates to a local site. In addition, the past history of recycling facilities is not unblemished. Superfund sites have been designated where underfunded, technically deficient, and/or unscrupulous "recycling" operations of years past left chemical disaster areas behind when they closed or declared bankruptcy. Convincing a community that recyclers who want to build a facility near them will somehow be different is not an uncomplicated task.

Most States that have undertaken the task of siting any of the various types of waste treatment facilities, or expressed interest in its outcome, have not been notably successful. New York State, for example, had to back down on a proposed site when unable to overcome local opposition. Massachusetts, while indicating to solvent recovery companies and waste management operators its interest in having them build a facility or facilities in the State, has not been successful in gaining local support for the sites proposed.

There are, however, two notable examples of success in siting waste management facilities in very different circumstances, one in North Carolina and the other in Arizona. In Arizona, the State selected a site on State-owned land (purchased from the U.S. Bureau of Land Management) and then advertised for the design and construction of a waste management complex. The Arizona Department of Public Health Services originally identified three sites that appeared to meet optimal geological, economic, and political criteria for development of hazardous waste management facilities. (The site finally selected, for example, although the least remote of the three, was six miles away from the nearest population center, a town with a population under 100.) Because of the political importance and difficulty of the issue, the final selection was made by the State legislature.

The final siting decision was controversial, in spite of the remoteness of the sites from major population centers. The battle in the State legislature over which site to choose was fought with considerable intensity. Whatever the disagreement over particular sites, however, there was substantial agreement in the legislature, with strong support from the Governor's office and the State Chamber of Commerce, that a site had to be chosen, and that only the direct involvement of the legislature would make that possible. As a result, the final vote was almost unanimous.

The siting of a waste treatment facility in North Carolina was far different from that in Arizona, and may be a more useful model for heavily populated and industrialized States that lack remote land areas. Rather than being sited far away from any center of population, this facility is to be within the city limits of Greensboro, in the middle of a heavy industrial zone in which there presently is substantial chemical manufacturing. Institutional factors that appear to have contributed to the success of this siting effort include the openness of the waste treatment company to thorough discussion of all aspects of the plan with the community, the existence of a well-informed, broadly representative community task force that had successfully tackled other environmental issues in the past, and the support of the Governor's Waste Management Board for both the need for and the location of the facility.

A number of factors are cited by those who have been involved in the less successful efforts at siting elsewhere. To say that the problem is due to the "not in my backyard" syndrome is both accurate and unilluminating. It is arguable that, by any reasonable definition, Arizona avoided everyone's backyard; North Carolina, by contrast, managed to find an acceptable -- and accepting -- backyard. The factors most frequently noted include poor communication and education, poor site selection, lack of clear purpose and leadership by State governments, and distrust of both the Federal and State governments and of the potential operators. With respect to communication and education, many of those involved in different efforts noted a failure of either the State or local governments to educate the community on the costs and benefits of the site and on its relation to the local job base. In other cases, the prospective operator seemed unwilling to enter into an open dialogue with the community about the prospective facility and its design and operations.

Two examples of poor site selection were noted in New England by some of those involved, one due more to the nature of the site, the other to the lack of coherence and credibility in the process. In one case, the developer proposed a small landfill for sludges, but the landfill was adjacent to a swamp, and the townspeople objected to the danger of contamination. In a case involving a solvent recovery facility, three potential sites in the prospective host town were nominated as being appropriate by the responsible State authority, but a fourth site was selected instead at the urging of the State's turnpike authority. This created skepticism as to whether relevant health and safety criteria were used in making the decision.

A few State government and industry representatives have raised the question concerning whether it would ease siting for recycling facilities if there were a change in the labeling of the permits for such facilities. In California, for example, the State created three categories of resource recovery facility permits. The first is essentially equivalent to RCRA permitting, while the other two involve less stringent requirements for those facilities recycling non-RCRA wastes. (See Appendix J for further information on California's programs.) One of the State officials involved in designing the program noted that the reason for establishing the first category of permits was to provide recycling facilities with a more positive label than that of a nonrecycling TSD facility (personal communication with Eric Workman, Engineer, California Dept. of Health Services, August 21, 1985).

Some reports have cited statistics that indicate overall national capacity for recycling is sufficient to meet current demand (Engineering Science 1984). The implication of such statistics is that obstacles to siting and expeditious permitting do not result in any inadequacy in the availability of recycling capacity. Such national capacity figures are misleading for three reasons:

1. It is difficult to say whether changes in the prices of virgin products, or in the cost of other forms of waste treatment and disposal, might make recycling more attractive for materials currently not recycled.
2. Overall capacity figures do not provide adequate perspective on discrete capacity with respect to specific types of waste streams.
3. National figures do not indicate the adequacy of geographic distribution. Transportation costs (and risks) make it uneconomic to move wastes for recycling over great distances. What distance would be reasonable generally will depend on the volume of material to be transported and the economic value of the recovered product relative to the cost of transportation.

Several States have created boards or commissions with mandates to locate sites for hazardous waste management activities, and to identify private operators for such sites or, if that fails, to plan for a more direct State role. Despite such efforts, siting seems likely to remain a significant obstacle to the development of expanded treatment and resource recovery capacity. The creation of a commission, as many States have discovered, is not sufficient. The rare successful siting efforts resulted where there was consistent government leadership and some form of effective public education and participation with respect to the need and criteria for siting. The safe and successful operations of those new facilities sited thus far may, in the long run, assist future siting efforts.

5.5.6 Permitting Issues

Companies involved in source reduction or recycling are concerned with the long and, especially, unpredictable delays that are often encountered in the quest for multiple permits. The uncertainty involved can detract from the economic viability of a project. The complaint of uncertain delays in obtaining environmental permits is common to most industries; it is, however, particularly problematic when it results in the use of alternatives for waste management that are detrimental to the environment.

Numerous permits may be required for a new facility that will be recycling hazardous wastes--Federal, State, and local. Such a facility is likely to require RCRA Part A and Part B permits for storage, and, where appropriate, disposal of hazardous wastes. Similarly, the addition of equipment for source reduction may require permits for "treatment" of waste. These permits (called treatment, storage, and disposal or TSD permits) must be in hand before construction of the facility begins. The permit program may be administered directly by EPA or, if the State has its own approved program, by that State.

The requirement for permitting treatment facilities under RCRA also creates difficulties for portable (mobile) treatment facilities. Such mobile units are moved to a new site frequently (every few hours or days). Presently, EPA defines the term "facility" as limited to fixed sites; consequently, the EPA's permitting program requires the owners of the portable units to obtain new permits each time the units are moved. The Hazardous Waste Treatment Council (HWTC) argues that such permitting takes up to two years and costs more than $200,000 (Inside EPA January 17, 1986). The HWTC has asked EPA to adopt an expedited permitting procedure for portable units based on the development of design and operating standards. Portable units meeting these standards would be permitted "by rule" by virtue of conforming to the requirements rather than undergoing a case-by-case evaluation (see Section 4.3 for a discussion of mobile treatment systems).

Small quantity generators also face difficulties because of the need to obtain a TSD permit for onsite storage. Although some of the wastes generated may be amenable for recovery, most recovery operations will accept a minimum amount of wastes. Thus, generators are forced to store wastes onsite in order to accumulate enough to be accepted. Under EPA's regulations, small quantity generators (i.e., below 1,000 kg/month, but greater than 100 kg/month) may store onsite for up to 270 days without a permit. This length of time may still be too short for some generators. For example, an electroplating operation in St. Louis, Missouri, finds it more economical to landfill the waste they generate than to send it to a recovery operation because of the costs and time of permitting. To ship to a recovery operation, the electroplater would need to pay $6,000 for 80 drums (personal communication from Robert Kirk, Fin-Clain Corporation, St. Louis, Missouri, to Industrial Material Exchange, Springfield, Illinois; January 15, 1986). To ship to a landfill, the cost is $5,788 for 80 drums. The electroplater has stated that the firm would prefer to pay the extra cost to ship to the recovery operation, thereby being relieved of potential landfill liabilities (see Section 5.2.3 for a discussion of the liability aspects). The waste in this example is F006, which is a sludge from electroplating operations. An analysis of the waste shows that it is not hazardous by characteristic of EP-toxicity. (See Section 5.5.7 for a discussion of delisting issues.)

In addition to the specific RCRA permits, numerous other permits may be required under Federal law, although these may be administered by the States. NPDES permits (administered by the States) will be required to meet direct effluent discharge requirements into waterways and pretreatment discharge requirements for effluents going to wastewater treatment plants.

A variety of air permits may be required, depending on the air quality status of the area in which the facility is to be located and on the pollutants to be emitted. Under the New Source Review (NSR) permitting program, if the facility is located in an attainment area for a particular criteria pollutant, it must go through the State and/or EPA-administered PSD (Prevention of Significant Deterioration) permitting process to ascertain that, in addition to not causing a violation of the air quality standards, it is not causing a violation of the increment of increased concentration of that pollutant allowed in the area. If the facility will emit relatively small quantities of the pollutant, the emission sources will only be required to meet applicable NSPS (New Source Performance Standard) requirements. Larger facilities may be required to install more stringent BACT (Best Available Control Technology). If the facility is in a nonattainment area for one of the pollutants it will emit, it must go through the nonattainment NSR permitting program, which will involve meeting either NSPS or more stringent LAER (Lowest Achievable Emission Rate) requirements, and possibly getting approval for offsetting reductions from other facilities in the area. Although this program is administered by the States in many cases, in numerous instances the State nonattainment NSR programs have not been approved, and direct EPA approval of permits must be sought. If the facility will emit any of the toxic air pollutants regulated under Section 112 of the Clean Air Act, a NESHAPS (National Emissions Standard for Hazardous Air Pollutants) may be required.

In addition, as noted in 40 CFR 270.3, it may be necessary in some circumstances to demonstrate that the facility causes no violation of Federal requirements for endangered species, State coastal zone management requirements, national historic preservation requirements, or national and scenic river requirements.

States may have their own additional permitting requirements, either involving matters such as water usage, land use, or highway right-of-ways, or involving requirements other than those in the Federal environmental programs. California, for example, requires recycling facilities to obtain resource recovery facility permits. Local governments may require zoning, building, or special use permits.

Any or all of these permit requirements may be time-consuming, especially in cases where there is little coordination among the various units of governments involved. The opportunity for expediting the process is best where a State has made a commitment to make the siting and permitting of resource recovery (or treatment and disposal) facilities a priority.

In Arizona, for example, because the development of a waste treatment and disposal facility is considered a State priority by both the Governor's office and the legislature, the coordination and processing of permits at the State level for a new TSD facility at a recently-approved site will be expedited. The State has also involved EPA from the outset to make sure that the handling of permitting at the Federal level will be fully coordinated with the State's effort. The State was therefore able to ensure prospective waste management contractors that there would be no unnecessary step in obtaining permits and licenses. There will be central coordination to keep all phases of the approval process on-track (with a target date of becoming fully operational by mid-1986).

In North Carolina, the State had a similar commitment to expedite the permitting of a treatment facility in Greensboro. Only one year elapsed between application submittal and approval.

5.5.7 Delisting Issues

The difficulty of delisting RCRA wastes is often noted as an obstacle to recycling some materials that do not create any significant threat to health or the environment. Some of the residual wastes from recovery operations, in particular, are listed as hazardous in EPA's regulations. Thus, disposal of some of these residuals is subject to RCRA requirements. In addition, some residual wastes may be listed as D-code wastes (wastes having one or more characteristics of hazardous wastes). Treating D-code wastes so that they no longer possess the particular characteristic of hazardousness (e.g., neutralizing a corrosive waste), would exempt the waste from RCRA regulation upon demonstration to the EPA that it no longer bears the characteristic. On the other hand, listed wastes (F-, K-, U-, and P-code wastes), in addition to being treated to render them nonhazardous, must undergo review by EPA via the delisting process.

To get a particular waste at a particular facility delisted, a company has two options. First, it can show that the waste does not contain any of the Appendix VIII RCRA toxic substances (either those that caused it to be listed or any others), and that it does not meet any of the characteristic waste criteria. Second, in the case of Appendix VIII substances, it may show that, while the waste contains traces of such substances, it does not pose any threat to health or the environment.

Delisting a waste is a regulatory action and therefore requires a full regulatory review, proposal, and promulgation. In the past, this difficulty has been somewhat mitigated by EPA's ability to provide temporary exclusions and/or informal waivers from enforcement. But under the 1984 RCRA amendments, all such actions must be finalized by November 1986. EPA has, by January 1986, granted three final exclusions for the approximately 631 petitions submitted; however, it has only approved 20 final delistings (with an additional 72 proposed and 26 currently written up for notice). Over 113 have been withdrawn, and 99 have become moot for a variety of reasons. The vast majority of the remaining petitions did not contain all the information EPA required to make the decision. In the case of some of the older petitions, this is compounded by the increased informational requirements under the 1984 RCRA amendments--for example, that the analysis must look at all hazardous components in the waste stream, not just those for which it was originally listed.

In an effort to expedite the processing of delisting petitions, EPA has taken several actions. The Agency has provided a guidance manual (early in 1985), which for the first time clearly stipulates for petitioners the information they must provide EPA in order for EPA to make its decision. It is also in the process of developing models (one of which has been proposed in the Federal Register) that provide a way for a company to assess whether its wastes are likely to meet the Agency's criteria for delisting before they go to the effort of submitting a petition. Finally, the Agency has augmented the staff for handling delisting petitions from 2 to 11.

5.6 Summary

The decision to employ waste minimization, although primarily an economic one, is also based on a company's awareness of alternatives and its perceptions of what such alternatives may entail. Until recently, landfilling offered the cheapest and most convenient method for handling waste. The restrictions of the recently promuglated HSWA may change this by increasing the economic viability of waste minimization. Despite incentives associated with these regulations, some barriers exist to waste minimization, mainly because of the economic difficulties in investing in waste minimization technologies; the economic/financial difficulties caused by regulatory requirements; real or perceived problems in complying with regulations associated with implementing waste minimization practices; real or perceived technological barriers; and lack of in-house expertise to implement existing technologies or methods. Summarized below are elements that are key to either promoting or inhibiting waste minimization:

- Economic Issues
  - A company can justify an investment in waste minimization if the present value of the resulting cash flow is greater than the current cost of the investment. Smaller firms are generally not able to raise as much capital as larger firms and thus face a greater constraint on their overall investment capabilities.
  - When the cost of reducing waste is less than the cost of producing the present amount of waste minus the cost of producing a lower, future amount, there is no motivation for investing in waste minimization.
  - Distance to a recycling facility and the costs of transportation play a major role in the decision to ship wastes offsite for recycling. In order for offsite recycling to be cost-effective, sufficient volumes must be recycled; in some cases, recyclers will not accept amounts below a minimum amount. Small-scale generators may not generate enough waste and must, therefore, store it onsite in order to accumulate a sufficient amount. Storage for more than 90 days (270 days for small quantity generators) requires obtaining a TSD permit, which is both time consuming and costly. Thus, landfilling may be a less costly (and thus more attractive) waste management alternative to recycling in such instances. Where it is possible to do so, however, small-scale waste generators have initiated recycling programs by consolidating their wastes, thus creating economies of scale that make recycling economical.
  - Investment in innovative waste minimization technologies is influenced primarily by the profit and risk associated with the innovation. Other factors include cost, capital availability, the adaptability of the technology, market and regulatory factors, and internal production

factors. A major incentive for investing in waste minimization technologies is the increasing cost and/or the banning of land disposal of hazardous waste, due to the requirements of HSWA.

- Liability Issues

  - Under CERCLA, generators may be held liable for damages from subsequent treatment, storage, or disposal of their wastes. The risk of future liability resulting from disposal of hazardous waste thus may serve as an incentive for instituting onsite waste minimization practices. Factors associated with this liability issue include the inability to obtain liability insurance and potential liability for cleanup costs. Because owners of landfills must demonstrate financial responsibility, under RCRA disposal fees may increase to cover what insurance normally provided.

  - Raw materials may be less costly than recycled waste materials because of the effect of CERCLA liability on transportation costs. The liability of a transporter of a hazardous substance generally ends upon delivery to its destination, provided it is not delivered for treatment or disposal. Conversely, a transporter delivering hazardous substances that may be recycled may be liable for damages from subsequent handling of the waste material or its residue. As a result, transporters may charge higher fees for delivery of hazardous wastes that are to be used in a process than for delivery of raw or virgin materials, since the former are not being delivered for "treatment or disposal," but rather for direct use in a process. The higher fees would be charged because of potential liability costs that the transporters' insurance may not cover. This presents an inhibition against using recycled materials, because of the costs involved. An exception may exist for recycled materials that are used directly without prior reclamation, since under EPA's revised definition of solid wastes such substances would not be required to be manifested.

  - For companies that lack in-house expertise, onsite waste minimization may not be an option. Liability issues may present a disincentive to ship offsite because generators may not know of the reliability of recyclers and may fear future costs they may incur for damages caused by subsequent handling of their wastes. In such instances, liability serves to inhibit such waste minimization practices.

- Company Attitude/Awareness Issues

  - RCRA, HSWA, and CERCLA have influenced corporate waste management officials to consider methods of reducing hazardous waste generation.

  - Corporate policies can influence waste minimization practices. To increase awareness and motivation, companies may provide waste minimization newsletters, cash awards, certificates, seminars, and workshops. Without upper management support, however, companies are unlikely to change. Many attitudes serve as disincentives for waste minimization. These include lack of familiarity with current production techniques, resistance to change, fear of product quality detriment, and management's view that waste minimization is a service function of low priority.

  - Many RCRA-related issues have been viewed by industry as disincentives to hazardous waste minimization programs. These perceptions include inconsistent implementation; complicated and costly permit application and information submittal procedures; time-consuming delisting processes; and storage requirements which do not allow enough time to accumulate a sufficient volume of waste to recycle without the need for a TSD permit. Other RCRA-related issues include waste stream analysis, mixture rule, and process recertification provisions.

- Consumer Attitude and Public Relations Issues

  - Consumer attitudes may play a role in affecting a company's decision to practice waste minimization if (1) there is an increased awareness of the environmental effect the manufacture of the product may have, along with the consumer's desire to improve the environment; (2) the consumer is willing to accept whatever changes there may be in product quality; and (3) the consumer is willing to sacrifice purchasing a product that may be cheaper and/or superior in quality.

  - Consumers may be more likely to purchase products that are made using waste minimization processes if they do not require a substantial financial investment. Thus, as an example, consumers may be willing to try a different paint, but not a different computer based on environmental issues alone.

  - Public relations may play a role with respect to a company's reputation. Companies that actively seek environmental solutions may benefit from being perceived as conscientious by both the community and by agencies that regulate them.

- Regulatory Issues

  - The requirements imposed by RCRA and other regulations may both inhibit and promote waste minimization practices. In particular, the HSWA requirements for land disposal restrictions, treatment standards, and technological requirements for landfilling (including corrective action for prior releases) may act as a significant impetus for companies that otherwise may not have considered waste minimization methods and techniques as an alternative.

- The revised Uniform Hazardous Waste Manifest Form contains a certification by generators regarding efforts to reduce the volume and toxicity of wastes generated. The act of certifying, by itself, may cause some companies to consider and implement waste minimization measures.

- Increased requirements and misinterpretations of the definition of solid waste may be disincentives to recycling. For example, many wastes recycled offsite and that must undergo reclamation prior to reuse must be manifested. Because of liability concerns, some generators may be reluctant to do this. Also, some members of the regulated community, as well as some State environmental agencies, have misinterpreted the regulations and feel that reclamation activities, by virtue of their being forms of treatment, require TSD permits. Companies, therefore, may be reluctant to practice onsite reclamation, feeling that to do so would require permitting. States who misinterpret the regulation in this manner may compound the difficulty by incorporating the misinterpretation of their version of the regulations.

- Technological and other requirements imposed by HSWA on all new and existing TSD facilities will likely lead to an increase in the cost of land disposal and an increase in closures of land disposal facilities; thus, generators are more likely to consider waste minimization practices.

- The problems associated with the siting of a waste treatment facility are significant obstacles to expanding treatment and resource recovery capacity.

- The possibility that a source reduction technique may require a TSD permit may constitute a significant barrier to such practices because of the time-consuming and costly nature of permitting.

- The uncertainty and unpredictable delays associated with obtaining appropriate permits from State and Federal agencies may reduce interest in waste minimization alternatives that require (or are perceived to require) RCRA permits.

- The difficulty of delisting RCRA wastes has also been cited as a disincentive to recycling some waste materials.

6. INDUSTRY EFFORTS TOWARDS WASTE MINIMIZATION

Sections 3 and 4 of this report characterized both source reduction and recycling practices from the technological standpoint, as well as in terms of the current and potential future extent of waste reduction. Section 5 characterized economic, motivational, and regulatory factors associated with the promotion or inhibition of waste minimization activities by industry.

This section provides a summary of general observations derived from the analysis of 115 cases of waste minimization reported in the literature. The same literature served as an information resource for Sections 3, 4, and 5 as well. This compilation represents, for the most part, successful waste minimization histories. The full compilation is included in Appendix H. A more exhaustive search may reveal more cases in which such practices were not enlisted; however, the literature tends to emphasize successes rather than failures. Future surveys may be necessary to more fully represent cases of failures.

6.1 Description of Information Base

The available data sources (LWVM 1985, Huisingh et al. 1985, Campbell and Glenn 1982, UN Compendium 1981-1985, Kohl et al. 1984, Garrison 1985, Sabrino 1985, 3M Corporation 1985) were reviewed; this review yielded a compilation of 115 distinct cases of waste minimization, which has the following characteristics.

- Ninety-four different U.S. companies provided 115 waste minimization cases.
- For the most part (77 cases), the sizes of the 94 companies were not reported; of the 17 that provided size data, 12 companies listed more than 10,000 employees and 5 listed less than 10,000. Judging by the nature of the product and other provided information, however, it is likely that 35 of the 77 companies that provided no size data are small- and medium-sized firms.
- Of the 58 companies that listed their SIC codes, 14 (24 percent) listed multiple SIC codes.
- Of the total of 89 different SIC codes reported, 37 (42 percent) were in the Chemical and Allied Product Industry category (SIC 28). The remaining reporting industries included Electric and Electronic Machinery (7 percent), Primary Metals (4 percent), Fabricated Metal Products (4 percent), and

Petroleum/Coal Products (4 percent). Also represented were textile, printing, rubber and plastic, and non-electrical machinery manufacturers. None of these categories exceeded 10 percent of the total respondents.

6.2 Observed Trends in Industrial Waste Minimization Efforts

The following observations summarize the analysis of the compiled 115 cases discussed above.

1. Most of the reported waste minimization efforts were initiated after 1976. Of the 31 cases for which the initiation date was provided, 25 (81 percent) were started after 1976 and 17 (55 percent) after 1980.

   Discussion: This observation is consistent with the trend noted in Section 5.3, i.e., that corporate environmental departments began to form in the 1970s in response to the regulatory pressure provided by the Clean Water Act, Clear Air Act, and RCRA. Additionally, the great majority of the waste minimization efforts (81 percent) were initiated after 1976, the year RCRA was authorized.

2. There are 53 cases for which the original objectives were stated. Of these, 39 (74 percent) reportedly were initiated with the primary objective of minimizing waste generation. The remaining 14 cases were initiated with the original objective of increasing yield or profit, e.g., by raw materials savings.

   Discussion: This finding appears to contradict the general notion consistently expressed by the participants of the Woods Hole conference (LWVM 1985) and others that waste minimization activities are synonymous with the efforts to increase yield and reduce raw material cost. However, it must be noted that all of the compiled cases were originally identified, characterized, and selected in the course of an information gathering process specifically focused on waste minimization. This may have reduced the amount of information provided about cases where the initial motive was yield maximization.

3. For many cases, more than one type of waste minimization technique employed was listed; a total of 268 waste minimization techniques were reported for the 115 industrial waste minimization cases. These techniques were categorized as shown in Table 6-1.

   Discussion: Process modifications and recycling appear to be the most popular techniques. Again, the results seem to contradict the expectation that better operating practices (good housekeeping) would be the most popular waste minimization option, because of its low cost and ease of implementation. Perhaps the reason for this is that good housekeeping is often the least effective option in terms of the amount of waste minimized; it is also the least-documented option.

Table 6-1 Characterization of Reported Waste Minimization Techniques

Type of technique	Total reported Cases	 Percent
Process modifications	113	42
Better operating practices	27	10
Product substitution/reformulation	13	5
Recycling	83	31
Treatment	32	12
Total	268	100

4. Within the cited recycling efforts, most were performed for onsite solvents recovery, followed by metal recovery, heat recovery, and the sales of waste for reuse in other processes.

5. Reduction efficiency was reported for 108 cases or individual techniques. The following statistics were obtained, as shown in Table 6-2.

   Discussion: Since in the majority of cases, waste reduction "efficiency" was not formally defined, some uncertainty exists as to the meaning and interpretation of "percent reduction." Still, it is observed that for a large number of cases (37 percent) a high percentage reduction (> 90 percent) was reported. This observation appears to be consistent with the previous observation that process modifications (usually the most effective means of waste minimization) are a dominant practice.

In addition to the quantifiable information given above, the following qualitative observations were made:

6. Large companies (cited in LWVM 1985) generally reported having internal waste minimization programs established as a part of formal corporate policy. Typically, the overall monitoring responsibility for the waste minimization program was assigned to the corporate environmental staff, with the initiation and implementation of the program assigned to the management of individual manufacturing facilities.

7. Most responding companies (LWVM 1985) consider technical elements of their waste minimization programs to be proprietary information.

8. Internal economic constraints are perceived to be the dominant "barrier" to waste minimization. This is closely followed by regulatory constraints (RCRA permit requirement for recyclable waste, the complexity of regulations, hazardous waste definitions, etc.). Technological constraints, e.g., lack of ready-to-use technology, rank third. Motivational constraints are rarely mentioned.

6.3 Capital Outlays, Annual Savings, and Payback Period

Cost information was provided for 40 waste minimization cases. For the vast majority of cases, the financial data numbers indicated that the waste minimization efforts have been highly profitable. Additional observations are given below.

1. Reported capital outlays vary widely between zero and $4,300,000. The breakdown within the 22 cases analyzed is shown in Table 6-3.

Table 6-2 Characterization of Reported Efficiency

Waste reduction efficiency (Percent)	Total reported Cases	Percent
> 90	40	37
70-90	18	17
50-70	21	19
< 50	29	27
Total	108	100

Table 6-3 Capital Cost Outlays

Capital cost	Total reported Cases	Percent
< $10,000	10	45
$10,000-$100,000	6	28
$100,000-$1,000,000	2	9
> $1,000,000	4	18
Total	22	100

2. Reported annual cost savings for the 40 cases range from $6,000/yr to $6,184,000/yr, with the following breakdown as shown in Table 6-4. Most savings were from lower disposal costs, lower raw material requirements, and sales of wastes.

3. Payback periods were observed to be less than 5 years. For 28 cases where the payback periods were reported, the range was between zero and 5 years, with the breakdown as shown in Table 6-5.

The compilation of cost statistics excluded the data from IBM Corporation (LWVM 1985), which provided an extensive list of waste minimization cases, mostly dealing with solvent recovery and mostly profitable. The data were excluded to avoid biasing the statistics toward solvent recovery.

6.4 Summary

Waste minimization by industry historically has been accomplished through efforts to maximize product yield and reduce the cost of raw materials. However, more recent efforts, in response to regulatory pressure, have been directed toward making waste minimization a primary project objective and a part of formal corporate policy.

Process modification appears to be the most frequently used technique, followed by recycling and waste treatment. Better housekeeping (or improved operating practices) were reported rather infrequently. The majority of cases reported high waste reduction efficiencies in excess of 70 percent. Economic constraints are perceived to be the principal barrier to waste minimization, followed by regulatory constraints and technological constraints.

Waste minimization appears to be profitable, with over 80 percent of the cases for which data were obtained reporting payback periods less than or equal to three years.

Table 6-4 Annual Cost Savings

Annual savings	Total reported Cases	Total reported Percent
< $50,000	17	43
$50,000-$100,000	2	5
$100,000-$200,000	10	25
$200,000-$1,000,000	6	14
> $1,000,000	5	13
Total	40	100

Table 6-5 Payback Periods

Payback period (years)	Total reported Cases	Total reported Percent
< 1	15	54
1-2	6	21
2-3	2	7
3-4	3	11
> 4	2	7
Total	28	100

7. GOVERNMENT AND NONINDUSTRY EFFORTS TOWARD WASTE MINIMIZATION

The Hazardous and Solid Waste Amendments of 1984 (HSWA) require that EPA's Report to Congress address the desirability and feasibility of performance standards, or management practices prescribed to effect the reduction of hazardous waste treatment, storage, and disposal. Initially, hazardous waste legislation and regulation in the United States addressed the problem of hazardous waste through control of its disposal. Now, however, States and nongovernmental entities have begun to recognize the need to examine alternative waste management methods that reduce waste generation, or its subsequent treatment, storage, and disposal. This recognition can most probably be attributed to the waste minimization provisions in HSWA, as well as to an increased awareness of the issue itself.

This section summarizes representative Federal, State, and local efforts to implement recycling and source reduction as waste management alternatives. In addition, the section presents a summary of nongovernmental and nonindustrial research into and promotions of waste minimization.

7.1 Congressional Initiatives

The primary initiative undertaken by Congress to promote waste minimization was embodied in HSWA (see discussion in Section 1). In addition to this legislation, other activities include studies conducted by Congressional agencies, including the Congressional Budget Office and the Office of Technology Assessment in response to requests from members of Congress.

7.1.1 Congressional Budget Office

The Congressional Budget Office has analyzed alternative waste control strategies proposed to achieve the national goals of the 1984 RCRA amendments. Waste-end tax systems were specifically considered as a method of encouraging a reduction in the amount of hazardous waste generated. Three basic alternative forms of waste-end taxes were identified:

1. Taxes based on waste treatment or disposal technology;
2. Taxes based on waste hazard; and
3. A flat tax based on unit of waste generated.

Each of the alternative waste-end tax forms would increase the costs of waste disposal, thereby encouraging reductions in hazardous waste generation. By varying the tax structure according to the treatment or disposal method, Alternative 1 would provide the most effective means of promoting the best treatment/disposal methods available. Alternative 2 would provide the most effective means of reducing the generation of targeted wastes. Alternative 3 would not change relative waste management costs, and thus would not encourage the reduction of one type of hazardous waste over another.

The waste-end tax is a mechanism for shifting the costs of hazardous waste generation to those who most directly benefit from hazardous waste production: the waste-producing company and the consumers of its product. Waste-producing companies would face increased costs, which would in turn result in reduced company profits, increased consumer prices, or both, depending upon the ability of the hazardous waste producer to pass cost increases along to those consuming the associated product.

7.1.2 Office of Technology Assessment

The Office of Technology Assessment (OTA) of the U.S. Congress has performed studies on the technologies and management strategies involved in the treatment of hazardous wastes, including efforts to reduce their generation. The OTA's analyses, findings, and conclusions are used to complement other research efforts in the hazardous waste management field. The OTA information transfer has indirect effects on the reduction of hazardous waste generation nationwide as well, as research is applied in industry and in State and Federal legislatures.

OTA specifically addressed the potential of end-product substitutions to reduce the quantity of hazardous waste generated. Five case studies were performed of specific end-product substitutions that were successful in reducing the amount of waste generated. These studies lend insight not only into the particular substitutions studied, but also into the general implementation problems and potential waste reduction benefits resulting from end-product substitution. OTA estimates that end-product substitutions could reduce hazardous waste generation by 20 to 80 percent, depending upon the end product (OTA 1983).

OTA is currently conducting a study on source reduction in response to requests from the following Congressional Committees: Senate Committee on Labor and Human Resources, House Committee on Small Businesses, House Committee on Science and Technology, House Committee on Energy and Commerce, and the Senate Committee on Environment and Public Works. As part of this study, OTA will (1) examine the state of technology available for source reductions; (2) assess the level of effort in promoting source reduction in States and their programs, as well as current Federal efforts; (3) assess information needs from the perspective of government and industry; and (4) provide policy options of what the Federal Government can do to enhance source reduction. The last item will include evaluations of regulatory, nonregulatory, and legislative options, as well as a review of what the Federal Government can do to complement State efforts to reduce waste generation. The report will be published in fall 1986 (personal communication with Kirsten Oldensten, OTA, January 10, 1986).

7.2 National Research Council

The National Research Council was established by the National Academy of Sciences to associate science and technology with the Academy's purposes of furthering knowledge and advising the Federal Government. The Council recently prepared a report analyzing actions that would accomplish the reduction in hazardous waste generation called for in the RCRA reauthorization (National Research Council 1985). The report centered on nontechnical, institutional factors; its conclusions are listed below.

1. Most waste reduction efforts in the U.S. are in their early stages. Many opportunities exist for reducing the generation of hazardous waste.
2. Substantial waste generation reduction can be achieved by employing relatively simple methods (typically emphasizing engineering or plant-specific circumstances) that entail modest capital expense.

3. The increasing costs of land disposal for hazardous waste are an extremely important impetus to companies implementing waste reduction programs.

4. The dissemination of information about successful waste reduction techniques and programs is an essential first step toward reducing future waste generation.

5. Waste reduction approaches other than direct regulation of manufacturing processes are needed. Regulations that are adopted should be administered consistently and predictably, and should be flexible enough to encourage the use of methods that reduce the generation of hazardous waste.

6. In the long term, as implementation of newer, more capital-intensive technology becomes necessary to further reduce waste generation, public policies will have to adapt to different considerations. Industry may require subsidies to help defray research and development and capital costs. Long research and development lead time necessitates an immediate beginning of research and development efforts.

7.3 Federal Agencies

The Federal Government has promoted waste minimization through (1) legislation that directs various agencies to carry out specific mandates, and (2) appropriations that fund national environmental activities. Although numerous studies on recycling and source reduction have been undertaken, the focus of this section is on a representative selection of the agencies and programs involved with hazardous waste minimization. These are as follows:

- The Environmental Protection Agency;
- The Department of Energy;
- The Department of Defense; and
- The Tennessee Valley Authority.

7.3.1 Environmental Protection Agency

The Environmental Protection Agency (EPA) is responsible for the implementation of laws, policies, and regulations associated with the major pieces of Federal environmental legislation. The Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or Superfund are the enabling legislation for EPA's hazardous waste programs and regulations.

While no program within EPA is specifically geared to source reduction and recycling, the Office of Solid Waste (OSW) has become the program most directly involved in waste minimization issues since the passage of HSWA. Other programs within EPA that either directly or indirectly influence waste minimization are the Office of Water (OW), the Office of Research and Development (ORD), the Office of Policy, Planning and Evaluation (OPPE), the Office of Emergency Response (OER), and EPA's involvement with the United Nations Economic Commission for Europe.

- Office of Solid Waste. The Office of Solid Waste (OSW) is charged with developing and implementing RCRA and its amendments, which promote waste minimization directly by mandating:
  - The inclusion on hazardous waste manifests of the generator's certification that waste quantity and toxicity are reduced to the maximum degree economically practicable;
  - The inclusion of descriptions of the generator's efforts to reduce waste volume and document actual reductions achieved in biennial reports to EPA;
  - The requirement that generators certify annually that they are minimizing waste quantities and toxicity to the extent feasible, as a condition of all treatment, storage, and disposal permits issued after September 1, 1985;
  - A provision for controlled correspondence to inquiries about whether particular activities may qualify as waste minimization practices. (HSWA do not permit EPA to interfere with or to intrude into the production process by requiring standards for waste minimization. OSW has taken action in responding to specific inquiries about these practices, however); and
  - The preparation of a Report to Congress on the desirability and feasibility of instituting performance standards, management practices, or other actions to "assure such wastes are managed in ways that minimize present and future risks to human health and the environment."

Waste minimization is indirectly promoted as well by land disposal restrictions and by increased technological requirements for new TSD facilities (discussed in Section 5.5).

- Office of Water. The Office of Water (OW) has controlled wastewater pollutants by requiring in-plant (source) reductions in several industries. Under the Clean Water Act (CWA), effluent limitations guidelines and standards are issued to control discharges of pollutants from industrial facilities (or point sources). The bases for the limitations in some of the guidelines and standards are chemical use minimization or substitution and water use reductions, which in turn reduce pollutant discharges. Although the wastewater itself is not a RCRA hazardous waste, sludges from wastewater treatment often are; thus, the effluent guidelines may serve to reduce some RCRA hazardous wastes associated with wastewaters.

- Office of Research and Development. The major activities of ORD in waste minimization include a small business/small quantity generator research program in ORD's Office of Environmental Engineering and Technology (OEET), an outreach program run by ORD's Regional Services Staff (RSS), waste reduction research conducted by the Hazardous Waste Environmental Research Laboratory (HWERL), and Congressional appropriations for research administered by ORD.

  - The OEET Small Business/Small Quantity Generator Research Program provides financial support for research and information efforts of agencies or associations working directly with small businesses. Its current efforts include two main focuses: (1) supporting the research efforts of State technical assistance programs (providing financial support to North Carolina's PPP program) and (2) providing funding to the Governmental Refuse Collection and Disposal Association to set up a clearinghouse to furnish information on waste management options to small businesses.

  - The RSS serves as a clearinghouse for the regions and States to field requests related to technical information or technology transfer that do not fall within other avenues of inquiry within EPA regions or headquarters (these are usually questions that involve more than one media or discipline within EPA). RSS has also entered into a cooperative agreement with the National Governor's Association to help formulate priority needs for EPA's long-term research program.

  - HWERL in Cincinnati is undertaking research on waste reduction and recycling technologies used by various industries, with particular emphasis on the printed circuit board industry and on solvent and metal recovery. HWERL is conducting additional research on performance data of treatment processes, which include some recycling processes. Technologies examined include sodium borohydride metals reduction, electrolytic recovery of in-process plating bath solutions, and activated carbon treatment of plating baths for reuse of bath materials.

  - Congressional appropriations for research are administered by ORD, although the research projects are carried out by EPA-recognized "centers of excellence" at selected universities in the U.S. One such project is concerned with waste minimization (among other issues) and is being carried out by Tufts University's Center for Environmental

Management (CEM) in cooperation with EPA's Office of Solid Waste. CEM has proposed to address foreign technologies and strategies to reduce waste generation, as well as to examine the technical and regulatory aspects of waste minimization in the U.S. The study will also focus on economic issues such as the relation between policy decisions affecting the use of particular waste management options and market responses (e.g., insurance providers not writing policies for non-sudden environmental damage resulting from land disposal of hazardous wastes).

- Office of Policy, Planning and Evaluation. The Regulatory Reform Staff of OPPE, in conjunction with the Office of Enforcement and Compliance Monitoring, recently issued a policy statement (50 FR 46504) that encourages environmental auditing - an idea that may indirectly promote waste minimization. Environmental auditing is a systematic, objective review by companies themselves of their operations and practices. Among other things, the approach could be designed to assess the potential for initiating waste minimization practices. (Appendix I contains this policy statement.) Also, the Integrated Environmental Management Division (IEMD) has developed a computerized hazardous waste management model that assesses the risks inherent in current hazardous waste management practices. It also evaluates the potential changes in risk resulting from alternative waste management strategies.

- Office of Emergency Response. Another of EPA's responsibilities is the implementation of CERCLA, known as the Superfund program. Because generators may be held liable for the costs of future cleanups under the liability provisions of CERCLA, the legislation provides an indirect incentive to reduce the generation of hazardous waste.

- United Nations Economic Commission for Europe. EPA participates in international efforts to minimize wastes produced by industry. The United Nations Economic Commission for Europe (UNECE) currently provides a compendium of low- and non-waste technology to serve as a means of promoting process technology changes that eliminate or reduce wastes, energy usage, or natural resource usage. The U.S. EPA has supported this effort by contributing five descriptions to the compendium and assisting the UNECE staff with other information as needed.

In addition to the above program activities, EPA is funding some State-conducted research on waste minimization, including research at the Industrial Waste Elimination Research Center at Illinois Institute of Technology and the Technical Assistance Program at Georgia Tech. EPA is currently considering a request made by the State of Maryland Hazardous Waste Facilities Siting Board to fund 50 percent of the cost of waste exchanges in the U.S. (see Section 4.3.2 for further information on waste exchanges).

7.3.2 Department of Energy

The Department of Energy (DOE) is involved with research and development on the combustion of wastes as fuels, as well as in the design of systems that conserve energy. DOE, through the Office of Industrial Programs (IP), executes the Industrial Energy Conservation Program, which promotes and sustains cost-shared research and development (R&D) to improve the efficiency of industrial energy use. The program was created under the mandates of the Federal Non-nuclear Energy Research and Development Act of 1974 (PL 93-577) to carry out the national energy policy, which emphasizes that energy conservation is an important resource and a vital component of a balanced and diverse energy supply system (DOE 1983a).

Within the IP, there are two major divisions: (1) the Division of Improved Energy Productivity, which conducts R&D in designing new systems that conserve energy, and (2) the Division of Waste Energy Reduction, which is involved with the combustion of wastes as fuels. The first concentrates on improving the in-process energy efficiency and productivity. Since ash from some of these combustion processes is hazardous, improving the energy efficiency of a system would also result in a reduction in the generation of hazardous waste, i.e., source reduction. The Division of Waste Energy Reduction supports R&D of energy-conserving technologies to recover and utilize energy from waste materials.

Some examples of recent projects undertaken by DOE include:

- Concentration of Electroplating Waste Rinse Water: Process Uses Energy Efficient Low-Temperature Evaporation. A vapor-recompression evaporator is being developed for use by the electroplating industry; the system has potential application for any industry using a high-temperature evaporative process (DOE 1983b).
- Energy Recovery from Industrial Solid Waste: Boilers with Multifuel Burners Can Use Refuse-Derived Fuel. Boilers retrofitted with multifuel burners that can be fired with industrial wastes as substitutes for or in combination with fossil fuel have been studied for use in industries that generate more than 10 tons/day of combustible waste (DOE 1983c).

- Energy Recovery from Waste Plastic: Converting Atactic Polypropylene to Fuel Oil. A pyrolytic process that converts atactic polypropylene waste to fuel oil has been developed for use by polypropylene producers in the plastics industry; the process has potential application to other types of plastic waste, including waste polyvinyl chloride (DOE 1983d).

These examples are not necessarily concerned with processes that generate hazardous waste; however, their results may have applications that extend to processes that do generate such wastes.

7.3.3 Department of Defense

The Department of Defense is involved in a wide variety of activities that parallel many industrial operations in the private sector, such as electroplating operations, painting and coatings, paint removal, degreasing, metal fabrication, and explosives. The nationwide practices of these activities make the Department of Defense (DOD) one of the largest generators of hazardous wastes in the country. DOD's waste minimization efforts thus may serve as a model for generators in the private sector.

Since the passage of HSWA, there has been increasing awareness in all sectors for the need to properly manage hazardous waste. As a hazardous waste generator, the DOD has made it a policy, since 1980, to limit the generation of hazardous waste through alternative procurement policies and operational procedures and, when practical, to reuse and reclaim wastes for the conservation of raw materials.

DOD's environmental efforts take place within different portions of this agency. The major environmental activities, as disclosed in conversations with DOD personnel, are:

1. The Defense Environmental Leadership Project (DELP) - an office created in 1983 to develop innovative solutions to the environmental problems of the DOD;
2. The Defense Logistics Agency (DLA) - an office within DOD that provides field support (such as hazardous waste disposal services) to the various DOD installations; and

3. The installations themselves within each of the services that develop solutions and procedures for handling environmental problems at the base and service levels through the service's "Logistics Commands."

Below are descriptions of each of these DOD entities, their functions, and their activities as they relate to waste minimization.

Defense Environmental Leadership Project

A recent DOD initiative was the establishment of the Defense Environmental Leadership Project (DELP). DELP was created in 1983 to develop innovative solutions to the environmental problems for DOD, with emphasis on improving compliance and minimizing wastes. One of DELP's efforts was to sponsor a three-phased project to evaluate current minimization attempts and to recommend future strategies to achieve hazardous waste minimization. Phase I of the project involved the evaluation of 40 case studies of industrial process modifications. In Phase II, DELP will select 18 of these cases for a detailed review. Finally, in Phase III, DELP will choose three cases called "projects of excellence," which will be promoted within the DOD (Higgins 1985).

An evaluation of 40 cases illustrating DOD's efforts at hazardous waste minimization revealed three factors that contribute to successful process modifications (Higgins 1985):

- There tended to be a "champion" promoting the project, allowing it to overcome technical or developmental problems and the inertia that tends to protect existing processes.
- Support for modifications was provided at a sufficiently high level of command to affect population and environmental policy decisions.
- Successful modifications usually required the reallocation of funds from operations or production activities to environmental protection.

Process modifications resulted in multiple advantages. In addition to reducing the amount of hazardous waste generated, other desired effects included improved product quality and production rates, reductions in overall costs, and decreased manpower requirements.

DELP recently published the report "Recovery, Reuse and Recycle of Solvents," which relates to solvent use and recycling (Boubel 1985). The report serves as a guide for service facilities and personnel to help increase use of solvents. Included in the report are case examples of successful solvent use by both service and civilian facilities.

DELP also promotes a program, administered by the Defense Productivity Program Office (DPPO), that provides up-front money to purchase such items as solvent stills and collection systems for hazardous waste reductions or recycling activities. The program, known as "Productivity Enhancing Capital Investment (PECI)," also provides incentives to allow the benefits, in excess of the cost, to be used by the installation commander (Boubel 1985). The DPPO operates under the Assistant Secretary of Defense Manpower.

The PECI program was established primarily as a means to "encourage waste recycling and reduction by setting up a system that rewards DOD installation commanders" (Boubel 1985). According to Carl Schafer, Director of the Environmental Policy Office of the Secretary of Defense, base commanders presently have no incentive to save money through waste reduction, because the base's budget will be cut or the savings would be returned to the U.S. Treasury (interview with Carl Schafer in Inside EPA, January 4, 1985). By returning the benefits to the installation commanders, there is an incentive to initiate recycling and waste reduction activities. To qualify to receive the benefits, the base commander would have to specify how the money would be spent, but any "reasonable, legal use would be acceptable" (Boubel 1985). This would result in less reliance on the services provided by DLA, which are described in further detail below.

Defense Logistics Agency

DELP's efforts often require coordination with both the procurement and waste generating activities of DOD. DOD delegated the responsibility for procurement of materials and disposal of almost all excess hazardous property to the Defense

Logistics Agency (DLA). DLA's field support, the Defense Reutilization Marketing Offices (DRMOs), provides free disposal service to the generating installations (bases).

Material sent to DRMOs must first be screened for possible use by other DOD activities. This reutilization phase of the disposal cycle can involve activities such as precious metal recovery from scrap metals. Materials that cannot be reutilized are either transferred, sold, donated, or disposed.

An example of a recent effort to enhance this disposal cycle is the Used Solvent Elimination (USE) program. The goal of the USE program is to eliminate the disposal of recyclable solvents as wastes by October 1, 1986. The program will shift the burden of disposal back to the generating installations or bases. The preferred mode of disposal will be to recycle the solvents either on or offsite. To encourage reuse, small stills will be used for such practices as paint-gun cleanup (resulting after solvent evaporation, in some cases, in a dry cake of almost pure pigment, which the paint manufacturers are interested in reobtaining), while larger stills will be available for large-volume recycling of such materials as Stoddard solvents and freon. In addition, there will be an emphasis on waste stream segregation in order to increase the percentage of recoverable solvent. Analysis has shown that many reclaimed solvents are capable of meeting military specifications. According to the USE program guidelines, however, the DRMOs should be used only when there are overriding reasons that rule out recycle. Thus, decisions to dispose of solvents through a DRMO would have to be reviewed by higher headquarters (a flag officer command) (Boubel 1985).

For the small fraction of solvents and still bottoms that cannot be recycled, the DRMOs will provide the traditional means of disposal. The USE program guidance would also allow disposal of small volumes (less than 400 gallons per year total of all solvents generated at one installation). The disposal of these small volumes, however, must be "by sale to a resource recovery facility or by transfer to an approved hazardous waste disposal facility" (Boubel 1985). The USE program allows the bases to devise their own waste management strategy. DRMOs would only handle the surplus that is nonrecyclable.

One disadvantage to the DRMO service is that, since the DRMOs collect hazardous waste from DOD facilities, "the true disposal costs [are] hidden from the user because they are paid by the DRMO, not the facility" (Boubel 1985). This practice may discourage the implementation of source reduction and recycling modifications, since any minimization costs are charged to production activities. The USE program eliminates some of this, but the problem of nonsolvent hazardous wastes remains.

To some extent, the PECI program mentioned above may serve to alleviate this problem. At one time, a plan similar in intent to the PECI program was developed within DOD as an economic incentive for the bases to minimize waste. The plan provided that allocations would be made to bases for the cost of disposal. Theoretically, if the bases were able to manage the waste for less money than the allocation, the extra money would still go to the base. The plan was not found acceptable at that time and was not implemented (personal communication with M. White, Defense Environmental Leadership Project, Washington, D.C., October 11, 1985).

Another possibility under investigation by DLA is the initiation of a waste exchange service implemented through the DRMOs. Waste exchanges would enable different bases, or even different functions within the same base, to learn what wastes are available or wanted. The system would facilitate the exchange of wastes that could be reused directly or with a minimum of processing. The waste exchange function would be operated through the DLA and, as currently conceived, would involve only intra- or inter-service exchanges as opposed to trades with private sector generators. It is possible, however, that this program could coordinate with the other nonprofit waste exchanges providing services to industry (personal communication with David Appler, DLA, December 20, 1985, Cameron Station, Virginia).

Installation Efforts

Hazardous wastes produced at DOD facilities largely result from metal-finishing operations, which include paint and metal stripping, surface cleaning, metal plating, and painting. Modifications investigated to reduce overall waste generation from metal-plating operations include: reducing dragout from processing baths, reducing rinse water flows, improving rinsing efficiency, recovering metals from rinse waters, and making raw material substitutions. Waste disposal associated with solvent cleaning has been reduced by segregation and eventual distillation. The implementation of promising new developments -- water-borne coatings, dry powder coatings, wet electrostatic painting, high solids coatings, improved painting techniques, and robotics -- has greatly reduced wastes and emissions associated with painting.

Paint stripping procedures for aircraft typically involve the spraying of acidic methylene chloride or phenolic strippers and subsequent washing of the paint/solvent mixture into the wastewater collection system. This produces large volumes of spent solvents and wastewater. Stripping via dry media blasting using recoverable plastic media has yielded some positive results. DOD has estimated that $100 million could be saved annually and millions of gallons of hazardous wastewaters per day could be avoided by switching to all plastic media paint stripping.

Despite the efforts of DELP, the military services that implement DOD's efforts tend to remain individualistic and depend heavily on the management at the particular base. The base commander may feel that he has little incentive to save money on daily operations such as disposal and environmental matters, which are considered service functions subordinate to the facility's commission (Boubel 1985). There are many creative ideas for minimization, but the lack of rapid technology transfer may contribute to reluctance to adopt these ideas. One major obstacle to effectively instituting waste minimization at DOD facilities is the difficulty of altering past practice. For example, in spite of the greater cost-effectiveness of plastic media paint stripping, and the elimination of the risk of damage to the plane, some bases are still building wet paint stripping hangars. Another example is that of spray-rinse versus standard rinse systems. Use of spray-rinse systems instead of standard rinse systems not only cuts costs, but also reduces the usual rejection rate for chrome plating from 40 percent to just 2 percent. Some bases continue to build the outmoded metal plating facilities, however.

Another area with a potential for increased waste minimization is procurement. Procurement management often acts without considering recycling options, however. For example, large quantities of hazardous waste on military installations actually are outdated virgin materials. Stringent purchase and use specifications of DOD policy could also be a major contributor to this problem, as illustrated by the used oil specifications. DOD's used oil specifications require the performance of an engine sequence test on re-refined used oil for each different source of batches processed. This requirement increases the cost of the used oil and makes it noncompetitive with virgin oil products.

DOD's procurement policies also may contribute to a lack of interest in waste minimization within government-owned, contractor-operated facilities, since they award no incentives for waste minimization. For example, military contractors in the aerospace industry operate on a cost-plus basis. A higher rate of profit is achieved for using high cost virgin materials as opposed to low cost recycled materials.

These situations may be changing, however, because of the adoption of a DOD-wide waste minimization strategy. Because HSWA require the generator to certify on manifests that a waste minimization program is in place, the DOD has recognized the need to plan such a strategy. As a result, the Joint Logistics Chiefs (JLC) of the Logistics Commands of the services developed a coordinated plan for hazardous waste minimization. In December 1985, the JLC presented a briefing to key DOD staff, at which the provisions of the waste minimization program were explained. Major elements of the program include: (1) development of an accurate reporting system, (2) a review of existing procedures and equipment for broad application, (3) improvements in the acquisition (procurement) process, (4) increased research and development, and (5) inter-service information exchange (technology transfer).

One interesting aspect of the briefings concerns the Air Force Systems Command (AFSC). According to the briefing package, most of the AFSC waste is generated by its government-owned, contractor-operated industrial plants. AFSC has therefore retained a consulting firm to evaluate the operations of these plants and to recommend alternatives for waste minimization. So far the study has revealed that alternatives to land disposal exist for over 90 percent of wastes generated. The AFSC anticipates the initiation of actions to implement study recommendations during FY 1986.

For goods or services produced for the various installations, waste minimization efforts may thus be implemented not only at the installation level, but at the DOD contractor services level as well. A similar idea is developed as a strategy option in Section 8.7. Considering that DOD is one of the largest generators of hazardous waste and exerts substantial market influence by its purchasing decisions, implementation of the various waste minimization strategies of DELP, DLA, and the Logistics Commands of the various services has the potential to yield substantial reductions in waste generation.

7.3.4 Bureau of Mines

The Bureau of Mines within the Department of Interior funds a research effort primarily intended to recover "critical and strategic" metals. The Extractive Metallurgy Technology Division is one of two divisions responsible for the Mineral and Materials Research activity within the Bureau of Mines. Research is conducted largely in-house at seven research centers to obtain information to improve unit operations such as grinding, flotation, roasting, leaching, and solvent extraction. The work produces data that may lead to improvements in resource recovery and productivity.

Specific research conducted includes the development of processes for extracting cobalt, precious metals, chromium, and titanium. The principal focus for the research program has been the recovery of mineral values from low-grade, complex domestic ores. The research has led to processes that involve recovery and reuse. For example, one research project concerned the recovery and reuse of chlorine from ferric chloride in the chlorination of leucoxene-type ilemite. Ferric chloride is produced as a byproduct in this process. Recovery and reuse of the chlorine content of the ferric chloride is desirable for economic reasons; the action also reduces the amount of waste disposed.

In addition, the Bureau of Mines examined the chrome etching process, with the initial goal of reducing the amount of chrome used in the process. The etching process involves dipping chrome-plated materials into an acid bath in order to add shine. The acid eventually becomes too impure to accomplish its purpose and must be discarded as waste. The Bureau of Mines research has led to an on-line process that removes chromium impurities from the acid, allowing the acid to maintain the necessary qualities longer.

7.3.5 Tennessee Valley Authority

The Tennessee Valley Authority (TVA) has implemented a Waste Management Program to minimize the adverse effects of hazardous waste on the environment and the community. The purpose of the program is to reduce waste generation, improve waste collection and transportation techniques, and enhance waste utilization as a resource in the public, private, and commercial sectors. It also seeks to improve the efficiency of treating and delivering water to consumers. The program receives $1.5 million in Federal appropriations per year. Project staff members are experienced in many areas, including the following:

- Community-based materials recycling;
- Municipal energy-from-waste (incineration, cogeneration, anaerobic digestion);
- Agricultural applications and fertilizing properties of waste (e.g., animal wastes, sewage sludge);
- Power plant and incineration residues and ash utilization research;
- Environmental control technology and environmental effects;
- Community and economic development aspects of waste management;
- Municipal waste composting;
- Integrated solid waste management system planning; and
- Chemical waste handling, treatment, and/or cleanup.

TVA activities address solid and hazardous waste, water supply, and wastewater management problems through direct technical assistance to municipalities, county governments, industries, educational institutions, and planning and development districts. These activities focus on improving the management and enhancing the efficiency of local solid waste, water supply, and wastewater systems.

The program features include rural solid waste collection, multipurpose collection vehicle design, organic waste utilization, materials recycling, energy from waste, wastewater treatment operator training, regional waste exchange, and public participation in regional hazardous waste management planning. Technical assistance is provided by TVA specialists in engineering, environmental and health sciences, community development, and planning.

Upon request, TVA staff will initially assess the local situation, including the diagnosis of special problems and identification of opportunities. Conceptual solutions are developed for potential adaptation to local circumstances.

TVA selectively enters formal partnerships with local governments and community-based groups to demonstrate solutions having regional or national significance. The monitoring and evaluation of the performance of demonstration projects is intended to produce information that is available and useful to others considering similar solutions to similar problems at other locations. The goal of this program is to allow effective solutions to be eventually incorporated into the marketplace.

Emphasis is placed on developing and implementing practices that embody resource conservation in waste and wastewater management and that involve acceptable ways of reducing the amount of waste and wastewater flow to treatment and disposal facilities. For example, the program encourages wastewater and waste management techniques that use land treatment, aquaculture, onsite waste disposal, waste stream separation, recycling, and other appropriate technologies.

The benefits of this program include avoidance of unnecessary expenditures, reduced consumer costs, energy and water savings, maintenance and repair of existing systems, and improved service to the public. The program aims at long-term economic development and environmental protection.

7.4 State and Local Efforts

Many State and a few local governments have encouraged waste minimization by establishing various programs and/or by funding mechanisms that promote recycling and source reduction. These strategies fall under six general categories:

- Regulatory programs;
- Fee and tax incentives;
- Loan and bond assistance;
- Grant programs;
- Information programs (information transfer, technical assistance, and waste exchanges); and
- Award programs.

The following section describes the strategies in general and includes examples of various State programs, with observations on problems and achievements where possible. In addition, more detailed descriptions of the programs for 11 States are provided in Appendix J. The States are: California, Georgia, Illinois, Massachusetts, Minnesota, New Jersey, New York, North Carolina, Pennsylvania, Tennessee, and Washington. These States were chosen because they appear to be most actively involved in waste minimization. They by no means represent the only State waste minimization efforts in the U.S.

Rating the effectiveness of each type of program relative to the others is not always possible, since in many cases it would be premature. The effectiveness of a program refers to what degree the program influences (1) the generator or TSDF community, (2) the cost efficiency of "preferred" waste management practices, or (3) the overall reduction of the hazardous waste generation rate. Since most of the programs are still in their infancy and thus have not reached full potential, this study cannot provide an evaluation of their effectiveness.

7.4.1 Regulatory Programs

Regulatory programs in the various States are in most cases modeled upon the Federal RCRA requirements. In some States, such as Texas and Arizona, the Federal regulations are adopted directly as the State hazardous waste regulatory program with little or no modification. In order for a State to obtain full authority for implementing its program, its regulations must be at least as stringent as the Federal laws and regulations. Table 7-1 presents a summary of the types of regulatory programs in the United States that encourage waste minimization. Table 7-1 also indicates the 40 States (as of May 1986) that have received full RCRA authority and those that are in the process of receiving it.

Waste minimization practices are encouraged through State regulations in two ways: (1) through exemptions from or relaxation of regulatory requirements if waste materials are recycled and (2) through restrictions applied to land disposal for certain waste materials and management practices.

For most States, exemptions for recycling practices are the same as the Federal requirements. Under the Federal regulations, for instance, the actual recycling practice does not require a TSD permit. (See Section 5.5.6 for further details on this issue.) The shipping of hazardous wastes offsite for recycling may require a manifest, and the storage of wastes for longer than 90 days, even if wastes are to be recycled, may require a permit. The practice of recycling wastes, however, is not a regulated activity (40 CFR 261.6 (c)(1)).

The difference between the State exemption provisions and the Federal regulations lies, for the most part, in how the regulations are phrased. The Federal regulations are phrased as requirements that apply or do not apply to specific activities. Under some State regulations, however, the nonapplicability for recycling is presented as an exemption and is sometimes listed in a separate section called "Exemptions." For example, Wisconsin's regulations provide exemptions from licensing as a treatment facility for legitimate reclamation or recovery of hazardous wastes, beneficial use or reuse, energy recovery, and other innovative recycling activities (Wisconsin Department of Natural Resources (DNR) n.d.). Similarly, hazardous waste in Minnesota that is to be "beneficially used, reused, or legitimately recycled or reclaimed" is exempt from many of the standards applicable to generators for other management practices and from most of the Minnesota Pollution Control Agency's permitting requirements (Minnesota Rules Part 7045.0125). New Jersey operations that recycle or re-refine precious metals

	RECYCLING EXEMPTIONS/VARIANCES	LAND DISPOSAL RESTRICTIONS	FINAL AUTHORIZATION	TENTATIVE DETERMINATION	APPLICATION SUBMITTED TO EPA	NO APPLICATION
ALABAMA					●	
ALASKA						●
ARIZONA			●			
ARKANSAS			●			
CALIFORNIA	●	●		●		
COLORADO			●			
CONNECTICUT	●				●	
DELAWARE	●		●			
DISTRICT OF COLUMBIA			●			
FLORIDA			●			
GEORGIA			●			
HAWAII						●
IDAHO						●
ILLINOIS		●	●			
INDIANA	●		●			
IOWA						●
KANSAS	●	●	●			
KENTUCKY	●	●	●			
LOUISIANA		●	●			
MAINE	●				●	
MARYLAND	●	●	●			
MASSACHUSETTS	●	●	●			
MICHIGAN				●		
MINNESOTA	●	●	●			
MISSISSIPPI			●			
MISSOURI	●		●			
MONTANA			●			
NEBRASKA			●			
NEVADA			●			
NEW HAMPSHIRE			●			
NEW JERSEY	●	●	●			
NEW MEXICO			●			
NEW YORK		●	●			
NORTH CAROLINA		●	●			
NORTH DAKOTA			●			
OHIO					●	
OKLAHOMA			●			
OREGON			●			
PENNSYLVANIA	●		●			
RHODE ISLAND			●			
SOUTH CAROLINA			●			
SOUTH DAKOTA			●			
TENNESSEE	●		●			
TEXAS			●			
UTAH			●			
VERMONT			●			
VIRGINIA			●			
WASHINGTON		●	●			
WEST VIRGINIA			●			
WISCONSIN	●	●	●			
WYOMING						●

Table 7-1. State Regulatory Programs and Final Authorization Status as of September 18, 1986[a]

[a] Source of Final Authorization Status: State Programs Branch, Office of Solid Waste, USEPA.

Sources: State Statutes and Regulations, Personal Communications with State Personnel.

will be excluded in early 1986 from the State's definition of "major hazardous waste facility," making it unnecessary to obtain that type of permit (personal communication with Kurt Whitford, Division of Waste Management, New Jersey DEP, on September 16, 1985, with regard to New Jersey Admin. Code 7:26-1.6). In Missouri, certification by the Department of National Resources suffices in lieu of a recycling permit (Wisconsin DNR 1983). In each of these instances, the State exemption essentially provides what the Federal regulations allow.

In situations where State regulations may be more stringent than Federal regulations and may require permits for recycling, relaxed requirements may apply. In the State of California, three classes of resource recovery permits are available (see Appendix J.1). The degree of information required in permit applications and the extent of processing requirements are related to the degree of hazard posed by the waste handled. This is intended to reduce the time needed for permit issuances and also to lessen the paperwork required of facility operators.

A similar situation exists in Kentucky where the law requires a hearing by the host local government before a permit can be issued for a hazardous waste disposal facility. A recycling facility permit can be obtained directly through the State government, however, thereby expediting the process (Kentucky Rev. Stat. Sec. 224.855).

Just as the relaxation of procedural requirements may act as an incentive for certain activities, the siting procedure itself can also be modified to promote minimization. For example, California changed the name of facilities that recycle hazardous waste from "hazardous waste facility" to "resource recovery facility." The new designation is intended to reduce the stigma attached to the former title, making siting less of a problem.

Another approach, which attempts to reduce the effects of local opposition, is being tried in Minnesota. The Minnesota Waste Management Board has selected "preferred areas" in response to the State's Waste Management Act of 1980. If a private developer submits a proposal for operating a hazardous waste recycling facility, the Board is empowered to mediate disputes between the developer and the

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local government as long as the proposal has been approved by the Minnesota Pollution Control Agency (personal communication with Wayne Sames, Minnesota Waste Management Board, January 7, 1986) (see Appendix J.5).

Although State and Federal requirements are generally the same with respect to recycling, some State disposal restrictions may be more stringent than those of EPA. Such restrictions may include: (1) bans on certain waste materials and/or types of management, (2) facility standards (e.g., liner requirements, ground-water monitoring), and (3) requirements that an approval be obtained from the regulatory agency before disposing of a particular waste stream. Land disposal restrictions indirectly encourage waste minimization, since the limitation and costs of waste management practices force generators to consider other methods, including recycling and source reduction.

Kansas, Illinois, and New York are examples of States that prohibited the land disposal of various solvents, dioxins, and other hazardous organics before HSWA called for land disposal restrictions on these substances. Wisconsin, like several other States, does not allow certain management practices such as underground injection or land treatment (personal communication with Barbara Zellmer, Wisconsin DNR, December 10, 1985).

As facility standard requirements tighten, regulatory compliance necessitates the implementation of more sophisticated technology. EPA has developed specific performance standards for each type of TSD facility regulated under RCRA. All State facilities must meet these Federal standards. Some States apply even more stringent specifications for liners, leachate collection systems, and ground-water monitoring. New Jersey, for example, requires landfills to be "constructed such that any leachate formed will flow by gravity into collection sumps from which the leachate will be removed, treated, and/or disposed" (New Jersey Admin. Code 7:26-10.8(d)1.v.). There is no such specification in HSWA.

Restrictions may be imposed not only by waste bans and facility standards, but also by the requirement for approval plans that allow the State agencies to screen wastes and waste management alternatives. For example, at Chem-Security

Systems, Inc. in Arlington, Oregon, a waste sample and profile sheet is submitted to the facility operator, who proposes the best method for waste to be managed. This proposal is then sent to the State agency for approval (Moellendorf 1985). Other States using this process are Illinois, which operates a Supplemental Waste Stream Permit Program (see Appendix J.3), and Kansas, which has a similar waste stream approval system (Wisconsin DNR 1983). Agencies may demand that the generator explain why wastes with potential for recycling and source reduction have not been similarly managed. This is the case in California where hazardous waste regulations contain a list of recyclable wastes. Generators who fail to recycle those wastes must provide written justification to the Department of Health Services (see Appendix J.1).

Two local governments in California, Santa Cruz and Sacramento Counties, have proposed regulations that may require generators to employ special consultants or inspectors to conduct environmental audits. The audit would include a facility evaluation and management recommendation that would then have to be implemented unless the generator supplies sufficient justification for not doing so (see Appendix J.1 for a more detailed discussion and Appendix K, which contains the proposed regulations of these two counties).

7.4.2 Fee and Tax Incentives

Many States currently offer several fee and tax incentives that may encourage preferred waste management alternatives. These financial incentives include:

1. Assessment of permit fees for the operation, treatment, storage, or disposal of hazardous waste;
2. Assessment of fees or taxes on the volume of hazardous waste generated or disposed (waste-end taxes); and
3. Assessment of taxes on raw materials used in processes that generate hazardous wastes (feedstock taxes).

In some States, additional incentives are provided by allowing exemptions and reductions from these assessments, as well as reductions and credits on sales, income, or property taxes for using more desirable waste management methods.

Waste fees and taxes serve not only to generate revenues for various purposes, but also in many instances to provide indirect incentives for using waste management alternatives such as recycling and source reduction, both of which ultimately reduce the amount of waste that is land disposed. The National Research Council (1985) reports that this is because they act as "mechanisms for making other waste management options more competitive with use of landfills for some waste."

Fees and taxes function in the same manner and often the two are synonymous, although they are usually implemented through different programs. For purposes of this discussion, a fee is a payment (generally associated with a permit) made to the State or the owner/operator of a TSD facility for the generation, transport, storage, treatment, or disposal of hazardous waste. If paid to the TSD facility by the generator, the fee covers costs reflected by State compliance requirements, the regional demand for service, and operational expenses, which include fees charged by the State to the facility owner/operator for permits, licensing, and renewals. Taxes are generally levied by the State treasury departments.

Fees can be "flat" (a single rate based on volume alone or even independent of volume) or graduated, according to the type of waste and/or the waste management practice employed. The graduated fee would thus reflect the potential hazard of the waste or its management method. In this respect, fee reductions and exemptions are similar to the graduated fee, because they lessen costs for using desirable waste management practices.

Among the States, several kinds of hazardous waste taxes are in place: feedstock taxes, flat waste-end taxes, and graduated waste-end taxes. The feedstock tax is a tax paid by the producers of chemicals and other raw materials that, when used in the production process, result in hazardous substances and hazardous waste (GAO 1984). Currently, no States directly tax the manufacture of such feedstocks, although four States, Florida, Maine, New Hampshire, and New Jersey, impose a tax on the transfer of petroleum and chemical feedstocks (personal communication with Mike Northridge, Office of Solid Waste, U.S. EPA, February 7, 1986). The Federal Government has also used the feedstock tax to fund Federal cleanup efforts of hazardous waste disposal sites as mandated by the

Superfund legislation (the Comprehensive Environmental Resource Compensation and Liability Act (CERCLA) (42 U.S.C. 9601-9657)). The feedstock tax is a reliable source of revenue, but has been criticized because it produces few or no incentives for waste minimization (GAO 1984).

Unlike the feedstock tax, the waste-end tax is levied on the generator or disposer of hazardous waste and can be flat or varied according to the hazard posed by the waste and/or its management method. The Congressional Budget Office (CBO), in its report "Hazardous Waste Management: Recent Changes and Policy Alternatives" (CBO 1985), examines the use of waste-end taxes to promote waste reduction. Four waste-end tax structures are analyzed at the Federal level with regard to ease of administration, ability to provide stable revenues, and effect on waste minimization, as follows:

- Tax System 1 varies taxes only on the basis of waste treatment or disposal technology, with a tax structure designed to encourage a shift away from certain undesirable land disposal techniques and toward more advanced treatment methods.
- Tax System 2 is graduated on the basis of waste hazard, management technique, and disposal method. Tax rates are designed to discourage the pairing of certain wastes with certain treatment methods depending on the hazard potential of the pairing.
- Tax System 3 (proposed by the Administration) also differentiates simply on the basis of management technology, but unlike Tax System 1, tax rates are increased each year to help assure a stable revenue stream.
- Tax System 4 makes no distinction among waste hazards or disposal choices, but simply places a flat tax on each unit of waste generated (CBO 1985).

The CBO analysis can be partially extended to State waste-end tax systems. When comparing them, Tax Systems 1, 2, and 3 appear more effective in encouraging waste reduction and management shifts, because Tax System 4 would affect only those industries with dilute, high-volume waste streams (CBO 1985).

CBO (1985) emphasizes that waste-end taxes serve both to generate revenues and to encourage waste reduction. These two goals potentially conflict with one another, because States may lose a significant source of revenue if land disposal were severely discouraged. This conflict, however, would be diminished if proceeds were required to go toward promoting waste minimization (CBO 1985), for example, in funding grant programs to companies investing in new equipment that results in a reduction of waste. In this case, decreased revenues would indicate that industries have reduced the amount of waste generated or switched to alternative disposal technologies. This scenario assumes, therefore, that waste minimization would have taken place, and the need for revenues would be diminished.

In theory, waste-end taxes should provide an economic incentive for more desirable waste management practices, and also generate monies, either for State Superfund cleanup or waste minimization efforts. Information to support this theory is not yet available, since many such programs are so new that reductions in waste volume have not yet been directly attributed to them. A study of waste-end tax systems in New York, New Hampshire, and California was conducted by GAO in 1984, but no definitive conclusion was drawn on whether waste-end taxes have achieved either objective. Despite the lack of direct evidence, however, many States are adopting such tax systems. In 1984, 20 States imposed waste-end taxes on hazardous waste generators (CBO 1985).

Other strategies to promote minimization are reductions, exemptions, and credits on property, income, and sales taxes, either for purchasing pollution control equipment or for implementing some form of minimization technology (Wisconsin DNR 1983). As in the case of fee and tax assessments, their effectiveness is dependent upon the overall economic effect on companies that make such investments. For example, resource recovery efforts that increase the product yield will also increase profits as well as the taxes on those profits. This increase in taxes may offset the benefits gained by tax credits. Another critical factor affecting the success of such strategies is that companies are aware that these incentives exist. Proper publicity is often a point of concern with those involved in promoting waste minimization. Because generators tend to choose the lowest cost options in managing wastes, assessing fees and taxes and granting reductions, exemptions, and credits do not guarantee that preferred waste management practices will be employed. Levies and their relaxations, if not sufficient to justify a preferred alternative, may encourage improper or illegal disposal (CBO 1985).

Table 7-2 summarizes fee and tax incentives employed by the States. Brief descriptions of programs that are unique or representative follow:

• Alabama	– $1/ton monitoring fee imposed on hazardous waste received for land disposal (Alabama Code 22-30-4(b)(3)).
	– $2/drum, $5/ton bulk weight local fee on hazardous waste entering one facility (personal communication with Daniel Cooper, Alabama DEM, November 22, 1985).
• Arkansas	– Set fee corresponding to quantity range assessed on in-State generators and persons accepting wastes from out-of-State (Arkansas Laws Act 479, Sec. 7).
• Connecticut	– $0.05/gal, $3.50/cu yd imposed on hazardous waste facility owners/operators for land disposal (Connecticut Gen. Stat. Sec. 22a-128).
• Florida	– Four percent excise tax on price of disposing, storing, or treating wastes paid by generators "for privilege of generating hazardous waste" (Florida Stat. Sec. 403.725).
	– Tax exemption allowed for wastes sent to State-certified recycling facilities (Wisconsin DNR 1983).
	– Feedstock tax on petroleum products entering State.
• Indiana	– Fee exclusions for companies engaged in recycling.
• Iowa	– $10/ton fee for wastes transported offsite, excluding water tonnage of wastes to be treated or recycled.
	– $40/ton fee for wastes land disposed offsite.
	– $2/ton fee for wastes destroyed or treated to render nonhazardous.
	– No fee imposed on waste reclaimed or reused for energy or materials (Iowa Code Title XVII Sec. 455B.424).
• Kentucky	– Waste-end assessment paid by generators for wastes being treated or land disposed offsite.
	– Wastes treated onsite charged one-half offsite assessment.

	– Fee exemption for companies engaged in recycling (Kentucky Rev. Stat. Sec. 224.876(7)).
• Louisiana	– $5/ton fee for onsite land disposal.
	– $10/ton fee for offsite land disposal (personal communication with Bill Deville, Louisiana DEQ, July 12, 1985).
• Missouri	– $25/ton fee for land disposed hazardous wastes or $2/ton fee for all other hazardous wastes transported offsite.
	– $1/ton generator fee.
	– Exemption for wastes reclaimed or reused for energy or material values.
	– $2/employee head tax assessed on companies generating hazardous wastes (Missouri Rev. Stat. Secs. 260.475, 260.380(10), 260.478).
• New Hampshire	– Recycled wastes exempted from quarterly fees (New Hampshire RSA 147-13:8).
• Ohio	– Waste-end tax on commercial disposal facilities for 6 percent of each charge, which varies according to disposal method (GAO 1984).
• Oregon	– Tax credit on excise tax liabilities for corporations, on income tax liabilities for individuals and partnerships, and on property tax for nonprofit organizations that produce energy or reclaim substances of economic worth from hazardous wastes; 50 percent of capital expenditures minus return on investment may be credited over facility lifetime or 10 years, whichever is shortest (personal communication with Maggie Conley, Oregon DEQ, October 10, 1985).*
	– Flat fee based on volume of hazardous waste generated per year, i.e., no fee for generating less than 100 cu ft/year; $100 for 35-99 cu ft/year; $350 for 100-499 cu ft/year; $625 for 500-999 cu ft/year; $1,500 for 1,000-4,999 cu ft/year; $3,500 for 5,000 to 9,999 cu ft/year; and $5,000 for over 10,000 cu ft/year (Oregon Admin. Rules 340-102-060).

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* Few applicants have applied for the tax credit because resource recovery usually results in net gains in profit, thereby weakening any gains from tax credit, as discussed above (personal communication with Bob Brown, Oregon DEQ, July 12, 1985).

	FLAT FEE AND/OR WASTE END TAX[a]	GRADUATED FEE AND/OR WASTE END FEE[a]	EXEMPTION/EXCLUSIONS FOR WASTE FEES/TAXES[b]	FEEDSTOCK OR OTHER TAX	CREDITS/EXEMPTIONS/REDUCTIONS ON SALES/INCOME OR PROPERTY TAXES[b]
ALABAMA	●				
ALASKA[c]					
ARIZONA[c]					
ARKANSAS	●				
CALIFORNIA		●	●[d]		
COLORADO	●				
CONNECTICUT	●				
DELAWARE[c]					
DISTRICT OF COLUMBIA[c]					
FLORIDA	●		●	●	
GEORGIA[c]					
HAWAII[c]					
IDAHO[c]					
ILLINOIS		●			
INDIANA	●		●		
IOWA		●	●		
KANSAS	●				
KENTUCKY		●	●		
LOUISIANA		●			
MAINE		●		●	
MARYLAND[c]					
MASSACHUSETTS[c]					
MICHIGAN					●
MINNESOTA		●	●		
MISSISSIPPI	●				
MISSOURI	●		●		
MONTANA[c]					
NEBRASKA[c]					
NEVADA[c]					
NEW HAMPSHIRE	●		●	●	
NEW JERSEY[c]				●	
NEW MEXICO[c]					
NEW YORK		●	●		
NORTH CAROLINA	●				●
NORTH DAKOTA[c]					
OHIO		●			
OKLAHOMA[c]					
OREGON	●				●
PENNSYLVANIA[c]					
RHODE ISLAND[c]					
SOUTH CAROLINA	●				
SOUTH DAKOTA[c]					
TENNESSEE		●	●		
TEXAS	●				
UTAH[c]					
VERMONT		●			
VIRGINIA[c]					
WASHINGTON		●			
WEST VIRGINIA		●	●		
WISCONSIN		●			●
WYOMING[c]					

Table 7-2. Fee and Tax Incentives to Minimize Waste for Hazardous Waste Generators and/or Disposers

[a] Assessed on Generators or Disposers by the State on a Waste Basis and Does Not Include Permit Application Fees

[b] Received for Implementing Source Reduction or Recycling

[c] Sources Identified No Fee and Tax Incentives That Promote Waste Minimization

[d] Exemption Is in Form of Fee Waiver if the Waste Is Rendered Nonhazardous Onsite

Sources: CBO 1985, EPA 1981, GAO 198[illegible], [illegible] DNR 1983, Bulanowski et al. 1981, Various State Statutes and Regulations, and Personal Communications with State Personnel

- South Carolina
  - Higher land disposal fee imposed on out-of-State generators; in-State fee of $5/ton is raised to $7.50/ton or higher as necessary to equal disposal fee in State where waste originated (Code of Laws of South Carolina Sec. 44-56-170).
- Vermont
  - $0.07/gal tax assessed on liquid, $0.009/lb tax assessed on solid hazardous waste destined to be reclaimed, recycled, or recovered.
  - $0.14/gal tax assessed on liquid, $01.7/lb tax assessed on solid hazardous waste destined for most forms of treatment.
  - $0.28/gal tax assessed on liquid, $03.4/lb tax assessed on solid hazardous waste destined for land disposal (10 Vermont Stat. Chap 237. Sec. 10103).
- West Virginia
  - Base waste-end fee reduced to 25 percent for those generators rendering wastes nonhazardous onsite.
  - No fee imposed on wastes beneficially used, reused, or legitimately recycled or reclaimed (West Virginia Code Sec. 20-56-4(a)).

7.4.3 Loan and Bond Assistance

Credit assistance, whether through direct State loans, guaranteed loans, subsidized interest payments for private loans, or bond financing, is a means of reducing the cost to firms of obtaining capital to make an investment. A State's objective in sponsoring any type of credit assistance program is threefold:

1. To minimize the adverse economic impact on target firms from investment expenditures;
2. To make funds available to those companies having trouble obtaining loans from the private market; and
3. To achieve a specific policy objective.

The overall policy objective in this case is waste minimization. Credit assistance through some form of subsidy from the State can promote source reduction and recycling when used to purchase waste reduction equipment or to build and operate recycling facilities.

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A business, whether a generator or a recycler of hazardous waste, will not implement waste minimization technology unless the venture promises to be profitable or is required by law. Frequently, such a venture has profit potential, but purchasing and operating costs may pose a significant financial strain, especially in the initial investment stages. If implementation were required by law, a company simply may not have the money to comply and thus would be forced out of business. Loan and bond assistance alleviates the financial difficulties by supplying the borrower with up-front capital, to be paid back over a period of time, usually out of earnings.

Private market loans could provide credit assistance, but the price is sometimes unaffordable to those who would need such services -- generally small- and medium-sized companies. The market rate of a loan is dependent on many factors, including the term and degree of liquidity of the loan, the rate of inflation, the degree of risk of the loan, and the loan placement costs. The last two factors are responsible for elevating the interest rates for small- and medium-sized companies. Such companies may not have an adequate credit history from which the banks can evaluate their risk in lending, and thus the risk premium is high. Additionally, the cost of investigating the credit history may be high compared to the profit the lender anticipates from the loan.

A State-sponsored program may be able to offer more affordable credit through private loan interest subsidies, loan guarantees, or direct loans. Each results in a lower cost loan because it ultimately reduces the interest rates. With interest subsidies, the State helps to pay all or part of the interest payment. With a loan guarantee, the State government insures the private lender against default by the borrower, making the loan a contingent liability of the State. This reduces the risk to the lender, who is then able to lower the risk premium. With a direct loan, the State loans its own funds. Since the State is more interested in carrying out its policy objective than in making a profit, it can charge a relatively affordable interest rate.

Private loan subsidies and loan guarantee programs place the burden of administration and funding on the private sector, while still enabling the State to specify standards for making the loan available. Such programs offer an advantage over direct loan programs by enabling the States to reduce their annual costs by passing on all loan placement expenses to the financial community. The private institution, however, makes the ultimate decision of whether or not to make the loan; it also has the power to set the interest rates. Thus, these programs may not help the intended beneficiaries. Thus far, California subsidizes interest rates for purchasing waste-reducing equipment; no States have actually established a loan guarantee program (personal communication with Jan Radimsky, California DHS, July 10, 1985).

In a direct loan situation, the State disburses funds and manages the program, giving immediate control to the government and allowing greater administrative flexibility. The State will set the interest rate, offer the optimal number of loans in optimal amounts, and choose the loan recipients after reviewing loan applications. Minnesota and New York grant credit assistance in the form of direct loans for pollution control equipment, which generally includes recycling and source reduction investments.

Funding for loan assistance may come from three sources: (1) appropriations, (2) special revolving funds established for the specific purpose (e.g., waste minimization), and (3) revenue bond financing. Funding through appropriations occurs as a result of periodic legislative budget directives. In California, for example, $5.2 million was set aside for the Hazardous Waste Reduction Incentives Account; half of this amount was allotted to the Pollution Control Financing Authority to grant credit to small- and medium-sized generators (California Health and Safety Code, Sec. 44558). A revolving loan plan requires a large initial investment, perhaps through an appropriation, but can be self-sustaining since repayments would enter the fund. The New York State Environmental Facilities Corporation (NYSEFC) is considering such a plan for that State's small- and medium-sized companies. Loans initially would be funded by the State or from NYSEFC fees, and repayments would enter a trust fund (NYSEFC 1985).

The third funding source, revenue bond financing, appears to be the most widely practiced of the three funding mechanisms. Several States have programs that use revenue bond financing to assist firms with the purchase and installation of pollution control equipment. In most cases, the financing extends to facilities related to the recycling and source reduction of hazardous waste. Missouri has found that bond financing enables the State to offer larger sums of money at competitive rates, since the purchasers receive preferential tax treatment on the earnings. The Missouri Environmental Improvement and Energy Resources Authority (EIERA) has operated a successful bond program for over a decade (over $1.5 billion in financing was provided for energy development and pollution prevention projects). That State is constantly looking at innovative ways to use industrial revenue bonds. For example, bonds could be issued strictly for waste minimization efforts, with proceeds going to a single recycling facility or into a fund accessible to many borrowers. These monies would be covered by company revenues and potential savings. Missouri has the ability at this time to issue bonds for $750 million (personal communication with Steve Mahfood, Missouri EIERA, October 7, 1985). Several other States have the authority to issue industrial revenue bonds that potentially provide funding for waste minimization efforts. These include California, Florida, Georgia, Illinois, Minnesota, Mississippi, New York, North Carolina, Tennessee, and Wisconsin.

The credit assistance programs in California, Illinois, Minnesota, New York, North Carolina, and Tennessee are discussed in further detail in Appendix J, Sections J.1, J.3, J.5, J.7, J.8, and J.10.

7.4.4 Grant Programs

Waste minimization grants are monies awarded to hazardous waste generators, processing facilities, and other public and private organizations to support waste minimization efforts, including research and development activities and/or demonstrations of recycling and source reduction technology.

State grants are a direct method for investigating new and existing technologies. They may support projects in full or match the monetary contributions of the beneficiary. "Challenge grants" (a term coined by North Carolina's Pollution Prevention Pays Program for its matching funds) are a means to stimulate generators in particular to investigate source reduction and recycling on a plant-specific basis, especially small- to medium-sized generators.

Supporting research, development, and demonstrations with grants allows the State to dictate what the work will address, as for example, specific State problems that may be neglected by the commercial and industrial sectors. Project results generally are made available to other companies. The principal advantage to offering challenge grants is that use is made of available in-house generator expertise.

The large investment required to implement grant projects and the need for annual appropriations are negative aspects of grant programs. Moreover, the return on expenditure is uncertain; the work is often time-consuming and may not always have practical applications. Generators also may delay spending their own funds on waste minimization in the present if there is a possibility of obtaining a grant in the future.

California, Georgia, Illinois, Minnesota, North Carolina, and Wisconsin offer grants for projects involving research, development, and/or demonstrations of source reduction and recycling technology (for programs in the first five States, see Appendix J, Sections J.1, J.2, J.3, J.5, and J.8).

7.4.5 Information Programs

Information programs gather, evaluate, catalog, and disseminate information that will assist industry in source reduction and recycling of hazardous waste. Such programs serve to educate hazardous waste generators and handlers and the general public on improved hazardous waste management. Information programs typically fall into three categories: (1) information transfer; (2) technical assistance; and (3) waste exchanges.

Information Transfer

An information transfer program works through such vehicles as studies, conferences, workshops, telephone hotlines, information clearinghouses, and training programs. These mechanisms help industry and the general public alike by

(1) recommending source reduction, recycling, and other treatment and disposal alternatives; (2) providing regulatory assistance; (3) studying hazardous waste issues; and (4) performing technical and economic feasibility studies.

One example of what initially started as an information transfer program is North Carolina's Pollution Prevention Pays Program, which has since grown to include grant and technical assistance strategies as well (see Appendix J.8). New York, California, Massachusetts, and New Jersey, along with several other States presented in Table 7-3, also have some form of information transfer.

Technical Assistance Programs

Technical assistance programs (TAPs) provide technical assistance to hazardous waste generators in all areas of hazardous waste management. One advantage of this type of information program is that it can be easily geared to a particular group of generators (e.g., small quantity generators or metal waste producers). Technical assistance usually is provided in the form of an onsite consultation, although in some instances such assistance can also be furnished by telephone. The consultation may consist of an assessment of a facility's operation, which includes such items as environmental compliance or specific advice on how a process could be altered to reduce waste generation. Because such consultations involve specialized knowledge of various industrial processes, qualified experts are needed, resulting in a high initial cost of implementation. The qualified experts are necessary, however, in order for the State to ensure that the TAP provides sound and accurate appraisals and advice.

The TAP is a specialized information program that generally involves more than just offsite and onsite consultations. Typically, seminars, technical workshops, and training programs are integral parts of a TAP. Because most small- and medium-sized companies lack funds and expertise to investigate waste minimization on their own, the TAPs have generally been most helpful to this group.

Disclosure of violations discovered during a consultation would certainly discourage the use of TAP services because of the fear of regulatory action or

	INFORMATION TRANSFER	TECHNICAL ASSISTANCE	WASTE EXCHANGE
ALABAMA	●		
ALASKA[a]			
ARIZONA			●
ARKANSAS[a]			
CALIFORNIA	●	●	●
COLORADO[a]			
CONNECTICUT[a]			
DELAWARE[a]			
DISTRICT OF COLUMBIA[a]			
FLORIDA			●
GEORGIA	●	●	
HAWAII[a]			
IDAHO[a]			
ILLINOIS	●	●	●
INDIANA[a]			
IOWA[a]			
KANSAS	●		
KENTUCKY	●		
LOUISIANA	●		
MAINE[a]			
MARYLAND	●		
MASSACHUSETTS	●		
MICHIGAN			●
MINNESOTA	●	●	
MISSISSIPPI[a]			
MISSOURI			●
MONTANA			●
NEBRASKA[a]			
NEVADA[a]			
NEW HAMPSHIRE[a]			
NEW JERSEY	●		●
NEW MEXICO[a]			
NEW YORK	●	●	●
NORTH CAROLINA	●	●	●
NORTH DAKOTA[a]			
OHIO	●		
OKLAHOMA[a]			
OREGON[a]			
PENNSYLVANIA	●	●	
RHODE ISLAND[a]			
SOUTH CAROLINA[a]			
SOUTH DAKOTA[a]			
TENNESSEE	●		
TEXAS			●
UTAH			●
VERMONT[a]			
VIRGINIA[a]			
WASHINGTON	●		
WEST VIRGINIA[a]			
WISCONSIN	●		
WYOMING	●		

Table 7-3. Information Programs That Promote Hazardous Waste Minimization

[a] Sources Identified No Information Programs That Directly Address Waste Minimization Within These States

Sources: State Publications and Personal Communications with State Personnel fines. Generators may also fear the exposure of proprietary information. Consequently, States operating TAPs have ensured that their programs are distinct from their regulatory agencies and promise strict confidentiality of generator information. Effective outside assistance requires complete knowledge of the production technology, which some industries may prefer not to disclose.

As presented in Table 7-3, seven States have some form of a TAP program. These are discussed in detail in Appendix J, Sections J.1, J.2, J.3, J.5, J.7, J.8, and J.9.

Waste Exchanges

The waste exchange, a third category of information program, is a means of connecting wastes via a matching service that companies can employ to advertise available wastes or to find waste materials they can use. In addition to helping to minimize the entry of wastes into the environment, waste exchanges can reduce disposal costs, save raw materials, and save the energy necessary to process those raw materials.

There are two basic types of waste exchanges: (1) information exchanges and (2) material exchanges. Information exchanges, the most prevalent, serve to match waste generators with potential users. Generators list the wastes to be transferred, and potential users list the materials desired. Material exchanges, in contrast, actually receive and handle wastes after playing a major role in arranging transfers. They are generally profit-oriented and are operated by private industry.

Information exchanges can be classified as passive or active. A passive exchange will usually issue a newsletter containing confidential listings of suppliers and users, potentially linking companies together. Most passive exchanges lack the resources, expertise, and legal authority to actively enter the marketplace seeking business. Letters of inquiry from potential users are forwarded to the originator of that listing. The originator initiates contact for the exchange to occur. The two parties then make arrangements for the transaction, reaching agreements on such things as quality, quantity, costs, and transportation without assistance from the passive exchange service.

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Active waste exchanges take a more visible role in transferring wastes between generators and users. Introductions are made through interviews and joint meetings held by the exchange or through computerized matchings. The waste exchange itself may sometimes provide information on an available waste by assessing its potential to be recycled. Such an assessment may include testing services as well as technical and marketing analyses.

Waste exchanges have rarely been operated by State governments alone because of industry's reluctance to provide information voluntarily to State regulatory agencies. Companies feel that an analysis of their waste and desired wastes may reveal proprietary information about their manufacturing process, and may disclose possible violations that could bring about regulatory action. Consequently, waste exchanges often are operated under the auspices of universities, business associations, and nonregulatory State programs on a regional basis, and are funded, in part, by State governments. To ensure a degree of confidentiality, the exchanges use codes rather than the names of generators and users. More information on waste exchanges is provided in Section 4.3.2.

State-supported waste exchanges are located in 12 States as presented in Table 7-3. Appendix J, Sections J.1, J.3, J.6, J.7, and J.8, provides more specific information on exchanges found in California, Illinois, New Jersey, New York, and North Carolina.

7.4.6 Award Programs

Award programs are low-cost strategies for recognizing and honoring individuals, companies, and institutions that have demonstrated outstanding achievement in hazardous waste management. North Carolina, Minnesota, and Alabama each have an award program in which projects eligible for nomination are those that reduce wastes, recover energy or usable material from wastes, or reduce the amount of waste destined for treatment or disposal facilities. Projects are judged on the criteria of environmental benefits, economic benefits (profits, annual savings, and payback periods), technological importance, and applicability to other industries and organizations. Georgia grants an award for achievement in resource recovery. The publicity associated with an award provides a waste minimization incentive to public and private institutions seeking favorable exposure. In North Carolina, Minnesota, and Alabama, projects are publicized in booklets, and winners are presented with certificates and tokens of achievement.

The award programs of Georgia, Minnesota, and North Carolina are described to a greater extent in Appendix J, Sections J.2, J.5, and J.8. Alabama presented its first awards in October 1985 during its first annual Pollution Prevention Pays Symposium. Descriptions of Alabama's winning projects are published in The Governor's Award for Outstanding Achievement in Hazardous Waste Management (State of Alabama 1985).

7.5 Nongovernmental, Nonindustrial Efforts

Nongovernmental and nonindustrial organizations have also examined the issue of waste minimization with varied approaches and degrees of effort. For the most part, they are nonprofit institutions funded in a variety of ways, including receipt of money from State and Federal governments. The following are a small sampling of those organizations that have made efforts to promote recycling and source reduction of hazardous waste.

7.5.1 League of Women Voters

1730 M Street, N.W.
Washington, DC 20036
Contact: Ms. Sharon Lloyd, Project Manager, Citizen Involvement
on Hazardous Waste Management
(202) 429-1965

The League of Women Voters sponsors a campaign to increase citizen involvement in several areas, including that of hazardous waste management. In 1985, the third year of the program, hazardous waste minimization was a major focus. Hazardous waste recycling and source reduction received substantial coverage in The Hazardous Waste Exchange, a quarterly newsletter published by the League and circulated to approximately 10,000 League members and industry representatives.

Hazardous waste minimization was also the topic at conferences sponsored by individual leagues on the State and local level and attended by business, government, and public interest groups. Video tapes and slide shows were used to present case studies of successful waste minimization practices. The New Jersey League sponsored a conference specifically for small businesses. In Maryland, a conference stressing regional cooperation in minimization was held; nine states participated. The League of Women Voters of Massachusetts presented a conference in the spring of 1985 in Woods Hole, Massachusetts, dealing with waste minimization and recycling. This was sponsored and funded by the U.S. Environmental Protection Agency in the amount of $33,000. Information presented in the conference was gathered from a survey of 21 major companies on their waste reduction plans and policies. The results of the survey were compiled in the booklet, "Waste Reduction, The Untold Story" (League of Women Voters of Massachusetts 1985). Another conference on waste minimization was held by the League in June 1986.

7.5.2 Pollution Probe Foundation

Pollution Probe Foundation
12 Madison Avenue
Toronto, Ontario
Canada M5R 2S1
Contact: Ms. Monica E. Campbell
(416) 978-6155

The Pollution Probe Foundation is a public interest group responsible for research, education, and positive policy advocacy geared toward protecting and improving the Canadian environment. Funding is provided through private donations and grants from other foundations. It currently is working to develop a regulatory program aimed at solving the problems of acid rain, drinking water quality, and pesticide safety. In the areas of hazardous waste management and toxic substances control, the organization has recognized waste minimization as a key strategy in combating problems inherent to each area.

In 1982, Pollution Probe published the book Profit from Pollution Prevention (Campbell and Glenn 1982). A guide to industrial waste reduction and recycling, it is a compilation of case histories that seeks to disprove the notion that reduction is technically impossible or prohibitively expensive. It is hoped that the book will encourage producers and regulators to investigate alternatives to traditional waste disposal.

The group also presents ideas on waste minimization at conferences, seminars, and symposiums. In an effort to reach a broader audience than those already aware of the alternatives, Pollution Probe arranges presentations at industrial conferences focusing on matters other than pollution control. Breaking the Barriers (Adamson 1984), a report on why Canadian industry has not embraced waste minimization, and a video tape are tools developed for use in these presentations. Pollution Probe's efforts extend to the international level; the group participated in the OECD environmental economic conference held in France and is currently involved with the UN environment program symposium on clean technologies in West Germany.

7.5.3 INFORM

381 Park Avenue, South
New York, NY 10016
Contact: Mr. Dave Sorokin
(212) 689-4040

INFORM examines business policies and practices as they affect specific issues in which business and the public share a mutual interest. Research efforts include problems of land use, water quality and conservation, energy technologies, pollution and toxic waste management, and safety and health in the workplace. INFORM's staff consists of 30 people, dedicated to issues dealing with the source reduction of toxic waste streams. Funding, predominantly from foundations and individual donations, amounts to approximately $100,000 per year.

INFORM has completed a study on waste minimization, which examined, evaluated, and compared the waste management practices of 29 chemical manufacturing companies within three States (Ohio, California, and New Jersey). The study focused on the degree to which information about wastes within a plant directed the plant managers' efforts to change waste management practices. The underlying premise of the study was that knowledge of the chemical substances' entering and leaving a plant necessarily directs decisions regarding the minimization of waste products, whether as air pollutants, water effluent, or solid/hazardous waste. The study contends that if companies do not have information on this mass balance, waste management practices are unlikely to change.

The results of INFORM's study have been published in the book Cutting Chemical Wastes (INFORM 1985). The study concludes that those 29 companies usually considered waste reduction as a "last resort" item. The lack of interest in waste reduction was attributed to several factors including costs, government regulations, technological barriers, and liability risks. Another factor was lack of awareness of the possible benefits (e.g., potential costs savings).

The study also identified examples of waste reduction and cited such cases as having prevented the generation of at least seven million pounds of wastes, with a corresponding cost savings of over $800,000 per year. Environmental regulations were identified as significant factors for both promoting and inhibiting waste reduction practices.

7.5.4 Environmental Defense Fund

Environmental Defense Fund
2606 Dwight Way
Berkeley, CA 94704
Contact: Mr. David Rowe
(415) 548-8906

The Environmental Defense Fund (EDF) is a national environmental group that conducts research on environmental matters and monitors the activities of environmental agencies and private sector companies. The nonprofit organization is funded through membership dues and other revenue-raising projects. EDF has five offices throughout the country, with the office in New York City serving as national headquarters.

EDF recently completed a draft study on State programs for waste minimization. This report, "Approaches to Source Reduction: Practical Guidelines from Existing Programs and Proposals," is expected to be available in final form by

February 1986. This study examines both current and proposed programs that encourage waste minimization in approximately 25 States, focusing more closely on those States with the largest and most active programs. Based on the analysis, EDF suggests recommendations to improve waste minimization practices.

7.5.5 German Marshall Fund

German Marshall Fund
11 DuPont Circle, N.W.
Washington, D.C. 20036
Contact: Maryanna Ginsburg
(202) 745-3950

The German Marshall Fund is an organization that sends interns from the U.S. to Europe to study various aspects of European policy, including hazardous waste issues such as treatment practices, economic incentives, and transportation.

A recent study on waste minimization found that European governments, specifically Denmark, France, West Germany, Sweden, and The Netherlands, are eager to use financial incentives to encourage waste reduction. These governments are active in sponsoring research and development and in providing technological assistance to companies producing toxic and hazardous wastes. The findings and recommendations of this study will be available in the forthcoming report, "Lessons from Europe."

7.6 Summary

Government programs at the Federal and State level to encourage waste minimization include many different efforts such as exemptions or relaxations of requirements for certain recycling activities, funding programs (such as grants and awards) to promote innovative solutions for reducing waste generation, information exchanges, technology transfer programs, technical assistance programs, and a variety of studies on the subject. Nongovernmental organizations are involved to a lesser degree than Federal and State agencies, being concerned more with studies, conferences, and recommendations. Their activities provide significant information that can be useful to governmental agencies, however.

Summarized below are key elements of Federal, State, and nongovernmental programs relating to waste minimization.

- Congressional Initiatives
  - HSWA require that EPA prepare a Report to Congress on the feasibility and desirability of performance standards, management practices, and other actions to require waste minimization.
  - The Congressional Budget Office (CBO) and the Office of Technology Assessment (OTA) have undertaken studies relating to waste reduction. CBO's study examined different types of waste-end tax systems as a method for encouraging waste reduction. OTA performed case studies on end-product substitutions as a means to reduce waste generation. OTA is currently conducting a study on source reduction, which will examine State and Federal activities and provide policy options on what types of programs the Federal Government can implement to enhance source reduction.

- National Research Council

  The National Research Council produced a report addressing nontechnical and institutional factors that influence waste reduction efforts.

- U.S. Environmental Protection Agency (EPA)

  Several programs within EPA are involved with waste minimization. The Office of Solid Waste (OSW) promotes waste minimization directly and indirectly through its regulatory programs mandated under HSWA (e.g., land disposal restrictions, increased technological standards for landfills). Effluent guidelines and standards prepared by the Office of Water also may serve to reduce some RCRA hazardous wastes associated with wastewater. The Office of Research and Development (ORD) is conducting studies on waste minimization. The Office of Policy Planning and Evaluation (OPPE) is undertaking a risk analysis of waste management practices. EPA also is a member of the UN Economic Commission for Europe, which provides a compendium of process technology changes that reduce waste, energy usage, or natural resource usage.

- Department of Energy (DOE)

  DOE's Office of Industrial Programs (IP) promotes research and development to improve the efficiency of industrial energy use. The IP consists of two major divisions: (1) the Division of Improved Energy Productivity, involved in designing new systems to conserve energy, and (2) the Division of Waste Energy Reduction, involved in using wastes as fuels. Current research projects include (1) concentration of electroplating waste rinse waste; (2) energy recovery from industrial solid waste; and (3) energy recovery from waste plastic (converting atactic polypropylene to fuel oil).

- U.S. Department of Defense (DOD)

DOD has made it a policy, since 1980, to limit the generation of hazardous waste through alternative procurement policies and operational procedures. These waste minimization activities are implemented through the Defense Environmental Leadership Project, the Defense Logistics Agency, and the efforts of the individual bases or installations themselves.

  - Defense Environmental Leadership Project (DELP). DELP develops innovative solutions to DOD's environmental problems, with emphasis on improving compliance and minimizing wastes. They recently published a report on recovery and reuse of solvents to serve as a guide for service facilities and personnel to help increase complete use of solvents. They are also promoting a program that provides money to bases to purchase solvent stills, collection systems, and other related equipment for hazardous waste reductions or recycling activities.

  - Defense Logistics Agency (DLA). DLA is responsible for procurement of materials and disposal of almost all excess hazardous materials. DLA provides a free disposal service to generating installations via the Defense Reutilization Marketing Offices (DRMO). Materials turned into DRMOs are screened for possible reuse by other DOD activities: this practice is being enhanced by the Used Solvent Elimination (USE) program, with the goal of eliminating the disposal of recyclable solvents as wastes by October 1, 1986. DLA is also investigating the possibility of initiating a DOD-wide waste exchange system to facilitate the exchange of wastes that could be reused on both an intra- and inter-base and service basis.

  - Installations. Individual bases are practicing waste minimization methods and techniques including bead blasting, use of water-borne coatings, dry powder coatings, high solids coatings, waste segregation, and others. Adoption of these practices has been slow, however, because of the difficulty associated with altering past practices. This situation may change with the adoption of a DOD-wide waste minimization strategy developed by the Joint Logistics Chiefs (JLC) of the services. Major elements of this program include (1) reporting system, (2) review of procedures and equipment for application, (3) improvements in procurement process, (4) increased research and development, and (5) inter-service information exchange/technology transfer.

- Bureau of Mines

Waste minimization activities primarily focus on resource recovery and reuse. The research program is directed toward the recovery of mineral values from low-grade complex domestic ores.

- Tennessee Valley Authority (TVA)

  TVA receives $1.5 million in Federal appropriations per year for implementation of its waste management program. This program is designed to reduce waste generation, improve waste collection and transportation techniques, and enhance waste utilization as a resource in the public, private, and commercial sectors.

- State Programs

  State and local governments encourage waste minimization by establishing and funding various programs. The effects of these programs on waste minimization are not always possible to quantify, but they are likely to result in some increase in such activities.

  - Regulatory. State regulations encourage waste minimization through two strategies: (1) exemptions or relaxations of requirements for recycling hazardous wastes, and (2) restrictions applied to land disposal. The exemptions or relaxations in many State regulations do not differ substantially from the Federal regulations, except that the State regulations (and descriptive literature about the regulations) are phrased differently and are presented in a manner that promotes recycling. Fifteen States employ exemptions or relaxations of requirements for recycling; 13 States' regulations contain restrictions for land disposal of hazardous wastes more stringent than those of EPA.

  - Fee and Tax Incentives. For fees and taxes to serve as incentives to minimize waste, they either may be (1) assessed for wastes generated or disposed, or (2) reduced or not applied on the basis of using preferred waste management methods. In some States, the second option may also include exemptions from or reductions or credits in sales, income, or property taxes. The immediate objectives of State fee and tax systems are to generate revenues and to make land disposal the least preferred alternative. At least 28 States impose waste fees or taxes; 4 States impose feedstock taxes; 11 States grant exemptions or reductions from such fees or taxes on the basis of use of preferred waste management methods; and 4 States grant exemptions from or reductions or credits in sales, income, or property taxes.

  - Loan and Bond Assistance. To minimize the economic hardship associated with source reduction and recycling, some States offer credit assistance through interest subsidies for private loans, direct State loans, or bond financing. Loan guarantees, another type of credit assistance, currently are not available in the States for costs associated with waste minimization efforts. Four States presently have direct loan programs; 10 States authorize revenue bond financing potentially applicable to waste minimization projects.

  - Grant Programs. Waste minimization grants are gift monies that serve as incentives for research and development and technological demonstrations for new and existing waste minimization technologies. Six States offer such grants.

- Information Programs. Information on waste minimization is made available through different types of information programs. The three most common programs are (1) information transfers, (2) technical assistance programs (TAPs), and (3) waste exchanges. Information transfer programs consist of publications, conferences, and telephone hotlines. Nineteen States currently have some form of information transfer. TAPs provide hazardous waste generators with specific technical advice on how their processes could be altered to reduce waste generation. Seven States operate active TAPs. Waste exchanges facilitate recycling by matching wastes available to materials wanted by companies. The objectives of an exchange are to help minimize the entry of wastes into the environment, reduce disposal costs, conserve raw materials, and conserve the energy necessary to process those raw materials. Currently, 12 States support waste exchanges within their boundaries.

- Award Programs. Four States currently operate award programs that provide recognition and honor to individuals, companies, and institutions that have demonstrated outstanding achievement in hazardous waste management.

- Nongovernmental, Nonindustrial Efforts

Nongovernmental, nonindustrial organizations promote waste minimization in various ways. Many instill public awareness and serve as sources of information. Organizations involved in waste minimization include INFORM, the League of Women Voters, the Environmental Defense Fund, the Pollution Probe Foundation, and the German Marshall Office. Reports on waste minimization are published by some of these organizations based on research including: case studies of industrial processes and practices; case studies and surveys of industrial plans and policies; studies of State efforts; and studies of practices used in foreign countries.

8. POTENTIAL STRATEGIES/OPTIONS FOR FURTHERING THE GOAL OF WASTE MINIMIZATION

Section 224(c) of the Hazardous and Solid Waste Amendments of 1984 (HSWA) requires EPA to report to Congress on the "feasibility and desirability" of new requirements that would "reduce the volume or quantity and toxicity" of hazardous wastes or "assure such wastes are managed in ways that minimize present and future risks to human health and the environment." The report is to include any recommended legislative changes that would further the realization of these national policy goals (as established under Section 1003(b) of RCRA). The section specifically refers to the possibility either of establishing standards of performance or other additional actions to require generators to reduce hazardous wastes. It also refers to required management practices or other requirements to assure the safest handling of hazardous wastes.

The Senate Report on HSWA explains "standards of performance" as "...similar to those under the Clean Air Act which would require all generators in a certain category to reduce the volume or quantity and toxicity of their hazardous waste at least as much as could be achieved through the application of measures that are available to generators in that category." Other methods to be reviewed would be any additional options available for requiring such reductions under Subtitle C of RCRA, including changes to the newly established HSWA certification and reporting requirements to Sections 3002 (standards of generators) and 3005 (TSD permit requirements) of RCRA.

The "management practices, or similar measures" are described in the Senate Report as including steps beyond the land bans enacted in HSWA. They would include "establishing preferred or required management practices [to] assure that hazardous wastes are managed only in those ways which the Agency determines are most protective of human health and the environment."

8.1 Identification and Organization of Options

The options that follow have been developed as possible means to meet the national policy objective of waste minimization added to Section 1003 of RCRA by

HSWA. These options include actions that would require amendment of authorities available to EPA under RCRA, as well as actions that could be mandated by regulation through current EPA authorities under RCRA and/or other environmental laws. As part of the assessment of the desirability of new binding legal or regulatory requirements to further the goal of waste minimization, nonregulatory strategies for meeting that goal have also been developed.

Some of these options are based on existing programs at State and county levels, while others have analogs in existing requirements under other Federal environmental laws. Still others arose out of information and analysis developed during the course of this study, and from recommendations and concerns expressed by those involved in government and by environmental and industry groups concerned with various aspects of hazardous waste management.

Where the options relate directly to existing non-Federal waste minimization programs, references are made to sections elsewhere in the report where those programs are discussed in greater detail. For example, where a State program contains elements that are the model for an option, reference is made to the section of the study where the nature of the State program is discussed in more detail. Referenced sections of the report will also provide, to the extent available, evidence as to the effectiveness of the particular program at the State level.

The potential strategies for furthering waste minimization are organized on the basis of the means by which they would affect generator activities in reduction, reuse, and recycling of wastes, including:

- Changes in the scope of applicability of hazardous waste management requirements (8.4);
- Performance standards, whether directly imposed or indirectly effected through a vehicle such as marketable permits (8.5);
- Changes in management practices (8.6); or
- Creation of economic or other incentives to encourage waste minimization investments or other activities (8.7).

An additional option is simply to implement currently mandated HSWA requirements, such as the land bans, and then to review how generators alter their waste generation and management practices in response (8.3).

The section on the scope of applicability of hazardous waste management requirements (8.4) considers the option of potential changes to the definition of "solid waste." Two of the changes considered involve only clarifications of the intent of the definition, while a third would involve some possible substantive revisions.

Options involving performance standards (8.5) would impose direct requirements on some or all waste generating activities in each industrial sector individually. They also would set general targets or limits for waste generation, or for the characteristics of the waste generated. The management practice options considered (8.6) include requirements restricting particular disposal practices, requirements related to the handling of wastes as they are generated, and requirements related to management control of the waste generation system. Beyond direct management or performance requirements, there are a number of options that primarily would be intended to create economic incentives for desirable waste generation and waste management behavior (8.7).

Some of the potential strategies for furthering waste minimization may require new legislative authority or regulatory action by the Federal Government, while others involve no new Federal requirements. Several options would require amendments to RCRA to provide EPA with the necessary legal authority, while others could be handled by regulation under authority already granted to the Agency, either under RCRA or under other statutes (e.g., TSCA). A number of other options could be implemented as policy by EPA without legislative action or regulatory rulemaking, either because they are essentially nonregulatory, or because EPA's role would primarily be one of supporting State efforts. The lines separating these categories, however, generally are not absolute. In some cases, for example, it is ambiguous whether EPA has the necessary statutory authority to implement a strategy.

In a number of options, the primary role envisaged for the Federal Government involves only informational and analytic support to State governments; thus, no new Federal regulatory or legislative action is needed. There are distinctions between options that are genuinely nonregulatory from the perspective of the State, generator, and/or TSD facility, and those in which the State develops its own legislative or regulatory requirements for generators and facilities (even though not as part of a required State program).

Ultimately, even a program that is nonregulatory in its operation (for example, an awards program) requires some form of legislative authorization for its funding and operation by whatever governmental entity is directly involved in its implementation. Direct implementation of a technical assistance program at the national level by EPA would require legislative action to appropriate funds, as do similar programs currently operating at the State level.

Table 8-1 provides a list of the options considered in this chapter, and an overview of the major way in which each would be likely to initiate or enhance waste minimization activities. It also summarizes the type of Federal or State action (whether legislative, regulatory, or nonregulatory) most likely to be required to effect each option. The options are categorized according to their primary characteristics. For example, even if a marketable permits program limiting waste generation sets limits based directly on performance standards, it also creates an economic incentive for waste minimization. For the purpose of the table, however, it would be classified under performance standards.

As noted above and indicated in Table 8-1, the determination of which options are legislative, regulatory, or nonregulatory for Federal or State governments often depends on whether the focus of implementation is State or Federal, and how clear the Federal statutory authorities are. On the legislative/regulatory section of the table, therefore, options are marked with respect to the most likely route of implementation, as discussed in the option. For example, the Federal role in developing tax incentives is likely to be limited to analytic support for State efforts, but a direct Federal role is at least conceivable and would require legislation. Enforcement bounties, on the other hand, are almost certain not to be implemented

OPTION	SECTION	PAGE NO	OPTION CATEGORIES					RELATIONSHIP OF OPTIONS TO FEDERAL AND STATE PROGRAMS					
			NO ADDITIONS TO CURRENT HSWA REQUIREMENTS	SCOPE OF APPLICABILITY	PERFORMANCE STANDARDS	MANAGEMENT PRACTICES	ECONOMIC OR OTHER INCENTIVES	REQUIRES NEW FEDERAL LEGISLATION	REQUIRES NEW FEDERAL REGULATIONS*	NON REGULATORY FEDERAL PROGRAM	PRIMARY FEDERAL ROLE SUPPORT STATE PROGRAMS	STATE PROGRAM REQUIRES REGULATIONS AND/OR LEGISLATION	NON REGULATORY STATE PROGRAM
RELIANCE ON AUTHORITIES AND REQUIREMENTS DEFINED BY HSWA	8	8-8	●					No	No				
MODIFICATION OF DEFINITION OF SOLID WASTE	8.4	8-10		●					Yes				
PERFORMANCE STANDARDS LIMITING VOLUME AND/OR TOXICITY OF WASTES	8.5.1	8-12			●			Yes					
WASTE GENERATION MARKETABLE PERMIT PROGRAM	8.5.2	8-16			●			Maybe	Maybe (Under TSCA)				
PROHIBIT OR RESTRICT GENERATION OF SPECIFIC WASTES	8.5.3	8-22			●				Yes (Under TSCA)				
USE OF EFFLUENT GUIDELINES TO INCREASE INTERNAL RECYCLING FOR GENERATORS	8.5.4	8-25			●			Maybe	Yes				
ESTABLISHMENT OF TOXICITY LEVELS FOR DELISTING PETITIONS	8.5.5	8-26			●				Yes				
REQUIRE INFORMATION FROM GENERATORS ON MATERIAL INPUTS USES AND DISCHARGES	8.6.1	8-26				●		Maybe	Yes		Federal or State	Yes	
USE OF PERMITS TO LIMIT AMOUNT OF WASTE THAT CAN BE LAND DISPOSED INCINERATED OR OTHERWISE TREATED PER GENERATOR	8.6.2	8-28				●		Maybe	Maybe (Under TSCA)				
REQUIRE SEGREGATED WASTE STREAMS FOR POTENTIALLY RECYCLABLE WASTES	8.6.3	8-30				●			Yes				
REQUIRE TECHNICAL AUDITS TO IDENTIFY WASTE REDUCTION POTENTIAL	8.6.4	8-33				●			Yes if Fed'l Program		Yes	Yes	
BAN THE LANDFILLING TREATMENT OR INCINERATION OF POTENTIALLY RECYCLABLE WASTES	8.6.5	8-34				●		Yes					
DEVELOPMENT OF INFORMATION AND TECHNOLOGY TRANSFER NETWORK	8.7.1	8-38					●			Yes	Yes		Yes
ESTABLISH PREFERRED PROCUREMENT PRACTICES	8.7.2	8-40					●			Yes			
DEVELOP IMPROVED WASTE MARKETING CAPABILITY FOR HAZARDOUS WASTE OF THE MILITARY SERVICES	8.7.3	8-46					●			Yes			
NON TAX FINANCIAL INCENTIVES	8.7.4	8-48					●				Yes	Yes	
TAX INCENTIVES	8.7.5	8-49					●		Yes if Federal Program		Yes	Yes	
WASTE END TAX	8.7.6	8-52					●		Yes if Federal[b]		Both Federal and State	Yes	
RATING OUTSTANDING RECYCLING FACILITY PERFORMANCE	8.7.7	8-55					●			Yes			
REDUCED LIABILITY FOR GENERATORS IF USING SPECIALLY PERMITTED RECYCLERS	8.7.8	8-57					●		Yes				
RECYCLED SUBSTANCES ACT	8.7.9	8-58					●		Yes				
EXPEDITED DELISTING PETITIONS	8.7.10	8-61					●			Yes			
ENFORCEMENT BOUNTIES	8.7.11	8-61					●				Yes	Yes	

*REFERS TO REGULATIONS BEYOND THOSE REQUIRED BY HSWA 1984

[b] AMENDMENTS TO CERCLA MAY RESULT IN THIS OPTION

Table 8.1 Categories of Waste Management Options and Their Relationship to Federal and State Programs

at the Federal level. Where the option is primarily for consideration of Federal action, no indication of State requirements is given (though, of course, nothing precludes States from implementing options that exceed Federal requirements).

It is important to note that neither the particular options nor the categories of options should be considered individually exclusive. Any number of combinations of options would be possible and might be desirable. Many States, for example, currently have programs that include waste-end taxes, a variety of tax and non-tax financial incentives, and a substantial information and technical assistance program (see Section 7.4 on State programs). All of these could be combined as well with a marketable permits program oriented towards generation (8.5.2) or disposal (8.6.2) of wastes, or both, or with specific performance standards (8.5.1). Choices of various possible combinations of options would be based, just as for individual options, on program objectives.

Ultimately, even a program that is nonregulatory in its operation (for example, an information exchange or awards program) requires some form of legislative authorization for its funding and operation by whatever governmental entity is directly involved in its implementation. Direct implementation of a technical assistance program at the national level by EPA requires legislative action to appropriate funds, as do similar programs currently operating at the State level. In organizing options by the kind of action necessary for implementation, therefore, a major consideration has been the role that EPA would be likely to play. To the extent that EPA's role under an option would be limited to providing information and technical assistance to the States, rather than setting the legal basis and determining the regulatory parameters for a program, the options have been listed as nonregulatory.

8.2 Potential Criteria for Deciding among Options

The objective in identifying options is to provide a wide range of possible approaches to achieve the goal of waste minimization. The strategies suggested in the various options vary widely in scope, complexity of implementation, and nature of the effect on generators and TSD facilities. Not all are mutually compatible or

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consistent. Some may further a particular facet of waste minimization, but have dubious or negative effects on others. Such considerations, as they apply to individual options, are noted in the relevant discussions.

A number of potential general criteria can be of use in evaluating and establishing priorities among the options presented, including:

- Likelihood of achieving the desired waste minimization objectives based, where possible, on available evidence from existing programs, and analysis of relevant economic, engineering, and/or legal factors;
- Possibility of unintended adverse effects on other aspects of the waste minimization program or on other environmental objectives;
- Ease of initiation -- both for the Federal Government and, where relevant, for State and local governments -- including the demand on both political and administrative resources to develop and gain approval for the program;
- Complexity of implementation, including administrative burdens for all levels of government and compliance burdens for the affected/regulated community;
- Successes and difficulties of analogous efforts in other programs;
- Cost of implementation, insofar as any reliable data or experience exist for projecting such costs, including direct costs to government, and direct and indirect costs to industry;
- Ease of enforceability for maximizing compliance with regulatory requirements;
- Probable degree of acceptance by implementing agencies or institutions, regulated (or otherwise affected) community, and the general public; and
- Degree of flexibility provided the regulated community in meeting the established environmental objectives.

8.3 Reliance on Authorities and Requirements Defined by the Hazardous and Solid Waste Amendments of 1984

HSWA require a wide range of changes in management practices for handling and disposing of hazardous wastes (see Section 5.5 for a discussion of requirements under HSWA). More importantly, for purposes of waste minimization, numerous small generators are brought within the RCRA regulatory framework for the first time. Also, a variety of new restrictions are imposed on disposal of hazardous wastes to try to reduce current dependence on disposal techniques that pose significant risks, present or long-term, to human health and the environment. In addition, generators are required to certify, both on the hazardous waste manifests and in biennial reports to the State or Administrator on the quantity and nature of hazardous wastes generated, that they have programs in place to reduce the volume or quantity and toxicity of hazardous wastes, and that they are choosing the most environmentally sound method of treatment or disposal.

Given the broad scope of HSWA, considerable time may be required to determine the effect of the changes, particularly the land bans, on the practices of generators, and specifically the extent to which they will undertake new efforts to promote source reduction and recycling. One option open to EPA would be to focus its current efforts strictly on implementation of the mandatory provisions of HSWA, and then, after there has been time to review the effects of those provisions, to examine what additional requirements would be needed to bring about greater waste minimization. One element of such a decision might be to spend all available resources, beyond meeting the HSWA deadlines, on vigorous enforcement, to attempt to eliminate noncompliance to the greatest extent possible. A particularly intense effort could be made to bring the newly-included small quantity generators into compliance as soon as possible.

Observations:

- Regulatory changes currently required by RCRA might be sufficient in themselves to encourage firms to minimize wastes, because of the increasing costs of disposal as landfilling restrictions come into place and because of the increasingly obvious risks of long-term environmental liability. But even if the decision were to impose no new regulatory or legislative requirements for the present, EPA might still consider the need for informational and technical assistance to small businesses. Many of these small businesses lack the resources to determine what waste minimization opportunities are available, even where there might be an immediate profit from such investments, or at least a very short time period before investment costs were recovered. (For more on the information needs of small businesses, see Section 8.7.1.)

- A number of generators and recyclers contacted for this study emphasized that more stringent and aggressive enforcement would greatly encourage increased reduction, reuse, and recycling. A few stated that regulations were not nearly as important as enforcement, and that current enforcement was too lax.

- Despite the long-term liability risks, many firms, especially smaller ones, are primarily concerned with short-run cash flows. Waste minimization may not always be the lowest-cost, short-term approach. In the absence of either additional regulatory requirements or financial incentives for installation of necessary equipment, therefore, companies may not undertake it.

- Companies mainly concerned with avoiding long-term liability rather than minimizing immediate expenses, may choose to use incineration to destroy wastes rather than looking for opportunities to reuse or recycle. While this may solve the individual firm's long-term liability problems, it will not lead to achievable reductions in virgin toxic materials in use.

8.4 The Scope of Applicability: Modification of Definition of Solid Waste and Associated Regulations

The scope of the RCRA hazardous waste regulations is determined by the definition of what is to be called "solid waste," as well as by any exemptions from regulation for materials encompassed by the definition. A certain difficulty arises from the need to write a definition that prevents hazardous wastes from escaping the regulatory system and being mishandled, while at the same time developing a definitional and regulatory framework that is not counterproductive with respect to waste minimization and recycling. (For a detailed discussion and summary of the revised (January 4, 1985) definition of "solid waste," see Appendix F.) Changes made from the proposed definition (48 FR 14472, April 4, 1983) to the final definition (50 FR 614, January 4, 1985) considerably restrict the classes of materials that can escape regulation. The definition itself was designed to close the "loopholes" that existed in the RCRA regulations. Although "sham" recycling has always been illegal, the regulations prior to the January 4, 1985 revision allowed characteristic hazardous wastes and commercial chemical products (listed in 40 CFR 261.33) to remain unregulated, provided that they were being "beneficially used or re-used or legitimately recycled or reclaimed." Thus, generators did not need to manifest the exempted wastes that were being recycled. There was no regulatory mechanism for ensuring that the exempt wastes were actually being legitimately recycled. EPA stated that such mechanisms were necessary to ensure that human health and the environment are protected (50 FR 618, January 4, 1985).

The option presented here involves the question of whether there might be changes to the definition that would provide greater encouragement for recycling without increasing risk to human health or the environment. The first two possible changes involve what may be only a clarification of the relationships of treatment and reclamation and of ingredient and feedstock with respect to regulatory requirements. The other raises the question of whether, under some circumstances, it might be preferable to use a lesser degree of regulation for recycling waste materials that are, for all practical purposes, equivalent to the virgin material.

8.4.1 Clarification of Relationship of Treatment and Reclamation

Under the final rule, the process of reclamation itself is currently unregulated. Thus, the fact that a facility carries on reclamation does not necessarily subject it to a requirement to obtain a TSDF permit. Reclamation is defined in 40 CFR 261.1(c)(4):

> "A material is 'reclaimed' if it is processed to recover a usable product, or if it is regenerated. Examples are recovery of lead values from spent batteries and regeneration of spent solvents."
>
> "Treatment" is defined in 40 CFR 260.10:
>
> "'Treatment' means any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize such waste, or so as to recover energy or material resources from the waste, or so as to render such waste nonhazardous, or less hazardous; safer to transport, store, or dispose of; or amenable for recovery, amenable for storage, or reduced in volume."

Discussions with both generators and State officials indicate considerable concern as to the intended relationship between these two concepts. There is particular concern that the intent of the definition is to leave reclamation activities unregulated only when they can somehow be considered not to constitute treatment. Reclamation is simply a subset of treatment, however. The concern of both generators and State officials is that, while reclamation as such may not be regulated, treatment is regulated, thus implying that facilities involved in reclamation will be subject to TSDF permit requirements because they are carrying out treatment. This confusion may discourage generators from undertaking recycling activities, which they believe will subject them to TSDF permit requirements for treatment. In fact, the act of reclaiming is exempted explicitly in 40 CFR 261.6(c)(1). This confusion could be alleviated by cross-referencing this part of the regulations in the definition of "treatment" in 40 CFR 260.10.

8.4.2 Clarification of Relationship of Ingredient to Feedstock

A second area where confusion on the part of States and generators could possibly be eliminated by further clarification is the relationship between "ingredient" and "feedstock." Under 40 CFR 261.2(e)(1), two of the exclusions from the definition are for (unreclaimed) materials that are:

> (i)...used or reused as ingredients in an industrial process to make a product, provided the materials are not being reclaimed....

and

> (iii)...returned to the original process from which they are generated, without first being reclaimed. The material must be returned as a substitute for raw material feedstock, and the process must use raw materials as principal feedstocks.

There is no distinction, however, between materials that are ingredients and materials that are feedstocks. The ambiguity of the relationship is illustrated by one of the examples provided in the supplementary information in the Federal

Register notice: "An example of the former practice -- i.e., use as an ingredient -- is the use of chemical industry still bottoms as feedstock" (50 FR 637, January 4, 1985; emphasis provided). This confusion could be alleviated by using one term or the other.

8.4.3 Greater Use of Concept of Equivalence in Determining Which Recycled Materials Should Be Subject to Regulation

The final rule on the definition of "solid waste" established some conditions under which recyclable materials may be excluded from regulation (see Section 5.5.2 and Appendix F for further information on this definition).* This option would exclude from the definition additional materials that are recycled if it can be shown that (1) the recycled materials function as raw materials in normal manufacturing operations or as products in normal commercial applications; and (2) the materials will be used within a reasonable period of time. An additional condition would be that, where the ultimate use involved burning for fuel or placement on land of commercial chemical products (e.g., as a constituent of fertilizer), it would be necessary to establish that the raw material which the recycled material was replacing typically was used for that purpose. Additional restrictions might be necessary to ensure adequate environmental protection, but they would still be short of the full requirements that result from regulation under the definition.

Principal areas where consideration of equivalence might reduce barriers to recycling are the following:

- Materials that were recycled through reclamation could be excluded (without requiring a variance for such exclusion) from the definition and exempted from regulation when reclaimed by the generator for use at the plant site at which they were generated (even if not in the original production process). (The Agency, to some extent, has already modified the rules to exclude from regulations those materials reclaimed in a closed-loop tank system; see 40 CFR 261.4(a)(8) in 51 FR 25471, July 14, 1986.)

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* Additional exemptions were considered in the proposed rule, including (1) hazardous waste being reclaimed by the generator or by a reclaimer for the reclaimer's own subsequent use, and (2) hazardous waste being reclaimed under batch-tolling agreements. Where a waste was reclaimed by the generator at a single plant site for return to the original process in which it was generated, the proposed definition would have excluded it from the definition of "solid waste" (see 48 FR 14477, April 4, 1983).

- Materials that are reclaimed under batch-tolling agreements, or similar leasing or processing agreements, could be excluded from the definition provided that a daily log of materials processed under such contractual agreements, at both the generator and the reclaimer, was both accurate and sufficiently detailed. Time limitations would be the same as in the proposal.*

- With a regulation as complex as the definition of solid waste, the clarity of interpretations can be of major importance. The more conjectural the interpretations of States or generators as to meanings and requirements under the regulation, the greater the possibility of results that are neither desired nor anticipated, either with respect to environmental protection or commercial efficiency. Attempting to predetermine each case, however, could eliminate flexibility.

- Enhancing protection of the environment and human health depends both on reduction of exposure to hazardous wastes and reduction of exposure to nonwaste toxic materials. The objective of reducing potential exposure to wastes tends to focus attention on prevention of any possibility of "sham" recycling or carelessness in waste management. But elimination of exposure to virgin toxics may provide a reason for greater emphasis on recycling and reuse of waste materials. The proposed rule established a significantly different balance with respect to these considerations than did the final rule, raising some question as to whether there were feasible intermediate steps. The question could, therefore, be one of emphasis. Should the rule be written to cover standard practices, with flexibility to curb infrequent abuses or should the rule be written, as it currently is, to cover every contingency, with flexibility to exempt those that can prior demonstrate the impossibility of such abuses?

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* In addition to the rules against over-accumulation and speculative accumulation, the proposed rule established time limits, for example, for the applicability of the batch tolling exemption. The generator was required to send the materials to the reclaimer within 180 days, and the reclaimer to return reclaimed materials to the generator within 90 days (48 FR 14495).

- While the regulations may provide increased impetus for a preference for virgin materials over those that are recycled, this may reflect a tendency built into RCRA and CERCLA. Specifically, these laws create a differentially greater liability for mishandling recyclable hazardous wastes than toxic virgin materials. This liability is reflected, for example, in the higher transportation costs for hazardous wastes. (The possibility of creating a further impetus for recycling by means of a Recycled Substances Act is considered in Section 8.7.9.)

8.5 Performance Standards

8.5.1 Performance Standards Limiting Volume and/or Toxicity of Wastes for Generators

Regulations could impose performance standards limiting the volume and/or toxicity of waste generation allowed per unit of production. The standard would apply either to specific industrial categories, or to specific waste-generating operations that may be a component of an industry. For example, a standard may be established for the electronics manufacturing industry for specific solvent wastes. Another standard for solvent wastes may be established for degreasing operations. In the latter example, standards for degreasing operations are not limited to any one industry.

Precedents for implementation of such a regulation exist within the programs associated with the Clean Air and Clean Water Acts. Under the Clean Air Act, New Source Performance Standards (NSPS) for new stationary sources of air pollution are established. The NSPS are emission limitations that apply to new or modified "sources" of air pollution in specific industrial categories. Some of the standards apply to pieces of equipment that are not specific to any one industry, such as fossil fuel-fired boilers. Other standards apply to equipment that is industry specific, such as particulate emissions from fluid catalytic cracking units in petroleum refineries. Emissions may be expressed in terms of pounds per million BTU heat input, or as a concentration limit of the total stack gas volume being emitted (e.g., 5 ppm). Some of the NSPS are expressed in terms of a practice rather than a standard; for example, some volatile organic liquids are required to be stored in floating roof storage tanks; other liquids must be stored in pressure tanks with vapor recovery.

Under the Clean Water Act, effluent limitations are established in a similar fashion for various pollutants under specific industrial categories. In both instances, standards, effluent limitations, or management practices are based on the best available control technology, with additional conditions (depending on the statute) that it must have been demonstrated in operation and/or be economically achievable. Each set of standards may be revised based on a periodic review of what constitutes "best" control technology; thus, standards for new or modified equipment may become more stringent over time.

This option proposes a similar approach: limitations on volume and toxicity of hazardous wastes would be established for specific industrial categories. These would be expressed either as a function of unit of production or of virgin materials introduced to a process or facility. The former standard may be more appropriate for process/product-oriented operations, such as production of printed circuit boards. In this instance, the standard may be expressed as pounds of a particular solvent component disposed per unit of product made. In the case of degreasing operations, the standard may be expressed as pounds of solvent (or component) disposed per pounds of solvent used in the degreasing operation. Like the air and water programs, the standards would be based on an evaluation of waste minimization practices and technologies available. This option would be applicable to existing as well as new or modified facilities or pieces of equipment.

While this option could be implemented under Section 6(a) of TSCA, the authority for this type of action is ambiguous and implementation might be unwieldy. Specific legislative authorization would probably be desirable.

Observations:

- This approach would establish standards for all to follow, eliminating uncertainty as to what constitutes waste minimization. If effectively enforced, it would contribute to waste reduction. If not effectively enforced, however, the program is likely to have the perverse effect of spurring illegal dumping.

- This approach has met with some degree of success in air and water programs; such programs are comparable to this option in that emission limits were established for specific industries based on industry practices and best available control technology. Comparison with air and water programs is not entirely appropriate, however. Air and water effluent streams are more easily categorized and generalized for purposes of establishing standards because (1) there are fewer pollutants of concern, and (2) end-of-the-pipe effluents are more amenable to prescribed technologies and limits than in-plant processes. There are some industries, such as the chemical industry, that use such a large variety of processes and equipment to make the same product that a uniform set of effluent limits or standardized management practices would be impossible to prescribe for the entire industry. Multiplicity of processes and products in the chemical industry has also proved to be a problem for effluent guidelines, as was evident in the initial proposal for the organics and plastics industry. In some instances, this approach would be most appropriate for companies that are small to mid-size within an industry that is fairly homogeneous in its operating and production practices. For other industries, however, the opposite may be true. For example, standards may be more readily established for some electroplating operations that are captive to large companies. Small to mid-sized plating shops, on the other hand, may not lend themselves as readily to regulation, since they are more of a batch type operation that generate waste streams with unpredictable components.

- Since the overall objective is to reduce human risk, it would serve little purpose to achieve a reduction of volume that results in a net toxicity increase -- a problem that could occur with some product or process changes. To avoid this, one should be able to measure toxicity of alternative waste streams against some common standard (as reduction in toxic effluents is measured by using copper as the standard for the cost-effectiveness evaluations for effluent guidelines). This would be an extremely complex undertaking, both scientifically and administratively.

- In order to develop such standards, it almost certainly would be necessary to first gather the kind of detailed information requested in industrial mass-balance surveys, such as those in New Jersey (see discussion in Section 8.6.1).

- This approach might be most readily implemented, at least initially, if limited, to new or modified facilities or pieces of equipment, or to highly standardized and commonplace industrial operations.

8.5.2 Waste Generation Marketable Permit Program

A waste generation permit program would involve granting permits to individual facilities to generate stipulated volumes of wastes. The amount of wastes that could be generated could then be held constant as the industrial base increased either by (1) holding constant the volume of waste that could be generated under any permit and requiring that new facilities buy permits for generation from existing facilities, or (2) allocating a certain volume of generation each year to permits issued to new facilities, while proportionately reducing the volume of waste that could be generated under existing permits so that there would be no net increase.

To achieve a gradual *reduction* in the total amount of waste generated, a small percentage reduction could be applied each year to the volume of waste allowed to be generated under any existing waste generation permit. If, for example, the objective were to achieve a two percent reduction nationally in waste generation for a given year, a two percent or greater reduction would be required in the amount of waste allowed to be generated under all permits currently held by existing generators. The extent to which reductions beyond two percent would be required, would depend on the volume of new source generation permits granted during the year.

A permit system could be designed either to deal solely with waste volumes or to deal with toxicity as well. To deal with the problem of relative toxicity, the most manageable option probably would be to create two or three classes of more or less toxic wastes, with specific permits (noninterchangeable) for each class. In principle, it might be possible to develop specific toxicity weightings for each waste stream relative to waste chosen as the standard (as, for example, copper is used as the standard for weighting reduction in toxic effluents in the cost-effectiveness analyses carried out for the effluent guidelines). A specific marketable permit would then allow a toxicity-weighted volume of waste generation, and the volume allowed under the permit would vary with the toxicity of the waste stream. Such a system would require a level of scientific precision that may be unattainable (and open to court challenge). It would also require a degree of detailed oversight of every change in production or process at each generator and of every market transaction involving the permits. These requirements are likely to render the system unworkable.

The permits allocated to facilities in such a system could either be marketable or nontransferable. A system of nontransferable permits has many of the same features, advantages, and problems as a marketable permit system. It lacks the flexibility that enables facilities to sell or purchase permit allocations according to their specific needs, however. Therefore, this option assumes that the system will be based on marketable permits.

Marketable permits would allow a facility to generate a specific volume of waste during the course of a year. In the event that a given generator carried out waste minimization efforts so that it no longer anticipated requiring the full volume allowed under its permit, it could transfer or sell that allocation to another generator. It might, however, prefer to hold its allocation in anticipation of future requirements created by annual percentage reductions applied to waste volumes allowed under the permits. Generators unable to reduce their wastes to the extent required by subsequent annual reductions, for either technical or economic reasons, would be able to purchase additional waste generation allocations rather than reducing production.

In order for such a permit system to be more than a paper exercise, there would have to be a significant penalty applied to any generator (and adequate enforcement to detect violations) for any volumes of waste generated in excess of those allowed by the permits.

One of the necessities to make such a system viable would be accurate data on actual volumes of waste generated. It would therefore be desirable to provide incentives to generators to produce accurate data on waste volumes. One possibility would be to allocate a small percentage increase in the volume of waste allowed under permits at any facility that had an environmental auditing program that would verify the accuracy of waste generation data. Such an auditing program would have to meet requirements predetermined by EPA. It might be desirable to require that, for purposes of receiving the additional allocation, the audit would have to be carried out by an independent contractor and periodically verified by EPA review.

It would probably be necessary to go to Congress for authorization to initiate a marketable permit system.

Observations:

There are a number of equity issues, technical difficulties, and structural problems that must be addressed if such an approach is chosen.

- Equity issues include the following:
  - How are past efforts by generators to minimize wastes to be treated? Is credit to be given for such past reduction and, if so, on what basis? If permit levels are allocated strictly on the basis of current levels of waste generated, those generators who have made efforts to reduce waste in the past will be at an unfair disadvantage.
  - Any efforts to credit past waste minimization will necessarily have to be judged on a case-by-case basis. Since most facilities are likely to apply for such credit, the administrative effort required to evaluate such claims could be overwhelming.
  - If permits are allocated to existing facilities, and new facilities must purchase waste generation permits from the existing ones, there may be some potential for exercise of market control by existing generators against new entrants.
- Among the technical difficulties that will require resolution are the following:
  - How should the baseline be established for allocation of waste generation levels under permits? It could be based on current or current-adjusted (for past minimization efforts) generation levels. This, however, may involve data and criteria problems noted below. It could also be based on performance standards for each industrial category. The technical, administrative, and time requirements for creating such performance standards may be substantial, however, as was the case in the development of appropriate requirements for permits under the NPDES program.

  - Even if existing facilities receive waste generation permits based on current generation levels, some other method will be necessary for allocating permit levels to new facilities, unless these facilities are to be required to purchase permits from existing generators, which raises the potential equity issue noted above. Should waste generation permits for new facilities be allocated on the basis of performance standards, or on some other basis?

  - How difficult will it be administratively to distinguish aqueous treatment systems that should be included under RCRA from those that should not (e.g., D002 corrosive wastes that may have been included by a facility in its list of hazardous wastes generated, but which are treated under an NPDES permit)?

  - What time period should be used for determining the baseline for an individual facility? Short time periods using the most recent data may alleviate the problem of evaluating questionable data, but may distort typical waste generation figures for a facility because of peaks or valleys in the business cycle. Facilities could be permitted to choose whether to use recent or long-term data, but this may compound administrative problems, and still leaves unresolved the adequacy of older data.

- The major structural problems are the geographic decision level for permit allocation and the potential administrative complexity of the program.

  - Will permits for new generators (or expansions), if they are not to be purchased from existing generators, be allocated on a national, regional, or State basis? One possibility that would be consistent with State delegation, yet would seem to alleviate some of the limitations on industrial development that might follow if each State were given a rigid allocation, would be to create a national pool from which each could draw annually. It would be necessary to set procedures for determining the drawing rights for each State.

  - Should permits be marketable only within a particular State or region or nationally? Nationally marketable permits would provide the greatest flexibility, including allowing for transfer of permits to facilities in areas with rapid development. But nationally marketable permits might lead to substantial reductions in waste generated in some parts of the country, while other parts of the country experienced no reduction, or even an increase.

  - How would the permit program be paid for? A generator permit program has significant resource implications. EPA estimates that there will be 189,000 generators above the 100 kg/month small generator limit (EPA Hotline). To meet the funding and staffing requirements for such an effort, it would probably be desirable to charge a fee for each permit to cover the administrative costs.

8.5.3 Prohibit or Restrict Generation of Specific Wastes

EPA could use its powers under Section 6(a) of the Toxic Substances Control Act (TSCA) to ban or otherwise restrict the manufacture, processing, or distribution of a chemical substance, or to regulate "any manner or method of disposal" or any chemical substance or mixture that "presents, or will present an unreasonable risk of injury to health or the environment." These powers could be aimed at the feedstocks that are responsible for particular waste streams, as well as at the waste streams themselves. In promulgating such regulations, the Administrator must assess the degree of health risk and the extent of human exposure, the benefits of the substance and the availability of alternatives for beneficial uses, and the economic consequences of the regulatory action.

In principle, EPA could use this authority to specify overall waste limitations or concentrations for manufacturers generating certain types of wastes. One example of the use of Section 6(a) authority is the ban on manufacture for most uses of chlorofluorocarbons for aerosol propellants. A similar type of authority has been invoked in a nonfederal context by California's South Coast Air Quality Management District to ban any emission of certain air toxics.

Section 6(a) authority is chemical- or waste stream-specific, and Section 6(a) rules have been developed for only five chemical substances (including PCBs, which was mandated by statute).

Observations:

- Use of Section 6(a) of TSCA could force the use of less toxic substitutes in any phase of production, or limit the volume or rate of generation of any particular toxic waste, but the chemical- or waste stream-specific nature of Section 6(a) regulations limits the effect of individual regulations, except in cases where the substances are widespread.
- Attempts to use this authority on a wide-ranging basis would be likely to produce resistance and litigation, particularly with respect to the requirement of Section 6(c)(1)(D) that the Administrator determine that the risk of injury to human health and the environment could not be reduced using any other regulatory authority.

8.5.4 Use of Effluent Guidelines to Increase Source Reduction and Recycling (CWA)

Under the Clean Water Act, EPA issues effluent limitations on wastewater discharges from various industrial categories. In particular, Sections 301, 304, and 307 of the Act (as amended in 1977) require EPA to develop effluent limitations guidelines, new source performance standards, and pretreatment standards based upon determination of the Best Available Control Technology Economically Achievable (BAT) for toxic pollutants. In addition, Section 402(a)(1) of the Act requires EPA to develop effluent guidelines for point-source categories using best engineering judgment. In making these determinations, EPA considers various technical alternatives, taking into account economics and technical feasibility. Included in these determinations are process modifications that reduce water usage, minimize wastewater generation, and/or substitute chemicals to reduce pollutant concentrations in wastewater. This option proposes that the effluent guidelines and standards be reexamined for additional consideration of the use of internal recycling and source reduction measures to effect reduction in RCRA hazardous wastes in addition to wastewater per each industrial category. Effluent limitations could then be revised to effectively require the use of additional source reduction/recycling within the process, and result in reduction of hazardous waste generation.

Observations:

- The reexamination and reworking of the present effluent limitations are probably a costly and time-consuming effort that may take several years to implement, especially since such a reexamination would have to be made on a process-specific basis.
- This option is likely to be met with resistance from industry, particularly in cases in which potentially expensive process changes may be involved and where modifications have already been made to meet previous guidelines.
- With the exception of a few industrial categories, the revised regulations would probably not reduce significantly the hazardous and solid wastes generated, since the limitations address wastewater discharges, which are frequently independent of solid waste discharges. For example, wastes such as still bottoms, tars, and baghouse dusts are not materials recovered from wastewater treatment. Of the wastes that do result from wastewater treatment, many are not suited for process reuse.

- This option may lead to substantial reductions in waste generation in only a few industries; however, for many industries the result may be marginal reduction of waste generation rates, despite increases in onsite recycling. A study to identify potentials for substantial reductions in waste generation appears necessary as a first step if this option were to be carried out. With respect to increases in internal recycling, such recycling is limited by the degree of contamination of the wastewater. Excessive contamination would prevent effective treatment.

8.5.5 Establishment of Toxicity Levels for Delisting Petitions

EPA could set predetermined numerical levels for toxicity of wastes or levels of hazardous constituents in wastes below which a waste would be considered nonhazardous. (For a discussion of the current process and status of delisting petitions, see Section 5.5.7.) (For a discussion of the possibility of simply expediting delisting of residuals from reclamation, see Section 8.7.10.) The limits would be set to represent levels below which human health and the environment are not believed to be threatened. This option would be a departure from the case-by-case evaluation of petitions that occurs now. Generators or facility owner/operators might only have to certify that the waste characteristics do not exceed the formally established thresholds. These thresholds would provide a basis not only for establishing that a waste was not hazardous by reason of the constituents for which it was originally listed, but also for determining (as required by HSWA) that there are no other factors in the waste that should cause it to continue to be listed (e.g., toxic solvents found in wastewater treatment sludges from electroplating that are largely free of the heavy metals which resulted in listing in the first place).

Possible approaches to this objective would be either to establish specific limits for all hazardous waste constituents (listed in Appendix VIII to 40 CFR 261), or to set specific limits for each of the constituents that could be contained in a specific waste stream on a RCRA waste code basis. In the second case, a petitioner wishing to have a K062 waste delisted, for example, would need to demonstrate that the constituents in the K062 waste are below the limits established for it. This approach would be based on the presumption that the same constituent may elicit a different degree of concern depending on the waste stream of which it is a part.

The objective of this approach to delisting would be to develop a quicker and more efficient delisting process, to the extent that this can be done consistent with the protection of human health and the environment.

Observations:

- Since residuals from reclamation operations are hazardous wastes until delisted, greater speed and predictability in delisting might increase the incentive for reclamation, especially onsite reclamation by generators.
- Specific toxicity limits might encourage generators to reduce hazardous levels in their wastes to meet the specified targets, but it may be difficult to ensure that such limits are maintained consistently over time. The enforcement effort to assure that waste streams were remaining within the established limits could be substantial (although this problem also exists for petitions considered on a case-by-case basis).
- The effort to establish such levels is likely to involve intensive use of both time and resources, and individual decisions could be controversial. The case-by-case approach was adopted because hazardous waste or hazardous constituents behave differently in different environments and in the presence of other wastes or constituents. The setting of a worst case numerical level might result in a threshold so low that virtually no one would be able to certify, and case-by-case considerations would still almost always be required. The analytical difficulty might be mitigated, however, by tieing such an effort to the establishment of treatment or pretreatment standards, which must be established to continue to allow wastes to be land disposed under the restrictions imposed by HSWA.

8.6 Management Practices

8.6.1 Require Information from Generators on Material Inputs, Uses, and Discharges

Under Section 8 of TSCA, EPA has authority to gather extensive information on chemical substances. Specific reference is made, among other things, to total amounts manufactured and processed, and a description of the byproducts generated by manufacturing, processing, use, or disposal. The Administrator may require, however, such other information as may be necessary for administering the Act. (Small businesses are exempt from this requirement.)

This authority appears sufficient to provide the opportunity for the Administrator to require a complete mass-balance analysis of chemical inputs, uses, and discharges or disposals. Requiring such information could provide an incentive for waste minimization.

New Jersey's Industrial Survey Project required a comprehensive report of such information from each plant covering each chemical in a survey completed in 1982. A second survey was supposed to be undertaken in 1984, but was delayed because of a legal challenge to the State's right-to-know law. The State still intends to carry out another survey, and perhaps to institute them on a biennial basis, but the timing depends on legal and legislative action.

In California, both Santa Cruz County and Sacramento County plan to require comprehensive mass-balance information on a continuous basis. (For more detail on the planned requirements of the two counties, see Section 7.4.1.) Sacramento County's zoning agreement, applicable to new facilities, includes the requirement for generators to provide a method to monitor and account for all hazardous materials at all times. This would include their arrival onsite through ultimate disposition, including material storage, movement, processing or fabrication, analysis, waste storage, treatment, discharge, product storage, and shipment offsite.

Sacramento plans to require not only basic process information, but regular updating of inventory, disposal, and other relevant records. In addition, generators will be required to monitor and report to the County any unexpected losses of material from any point in the process.

For each facility, Santa Cruz County will require comprehensive mass-balance environmental audits and regular reports. The Santa Cruz draft ordinance on hazardous materials is provided in Appendix K. Parts V through VII of this ordinance address the hazardous materials management plan, the hazardous materials disclosure form, the responsibilities of generators, and inspections and records. The hazardous materials management plan is to provide an audit that will include:

- A complete list of hazardous materials that will be stored, produced, or used in production, assembly, and cleaning processes;

- Diagrams and descriptions of all hazardous materials flow-through processes, waste generation, and treatment; and
- Estimates of the type and volume of hazardous materials that will be incorporated into final products, discharged into the sewer, released into the air, or transformed into hazardous wastes (Santa Cruz draft ordinance).

Both counties hope that the result of requiring this information will be substantial minimization of waste from the generators.

Observations:

- Requiring companies to manage information about hazardous materials with more precision than would otherwise happen could make companies more aware of inefficient use of raw materials. It could lead to efforts by generators to reduce these material losses -- especially where the materials have significant value.
- Tracking actual disposition of all pollutants and wastes into the various media encourages attention to the overall environmental impacts of a particular manufacturing process, rather than isolated consideration of each separate impact.
- Since companies will be aware that regulatory agencies will be reviewing their disposal and discharge records, they are likely to be more careful in management of wastes in order to avoid regulatory problems.
- Regulatory agencies would be able to gain a better grasp of where an area faced environmental hazards, or where a facility appeared to have material losses that were not accounted for. For sources with enormous quantities of materials throughputs, however, the benefit would be lessened. In such cases, minute inaccuracies in percentage estimates and measurements could result in substantial variations in unaccounted for materials.
- Regulatory agencies could also more effectively project disposal, treatment, and recycling facility capacity requirements.
- A single comprehensive data collection of this kind, such as that carried out by New Jersey, would be a massive effort at the Federal level. For EPA to gather information with the frequency proposed by the counties in California is probably not feasible.
- Enormous resistance could be predicted from industry to any collection of this kind of information, including likely challenges as to whether this extensive a collection of information is really necessary to carry out the purposes of TSCA, or whether it might be prohibited under the Paperwork Reduction Act.

- Such information could provide both technical assistance programs and regulatory agencies with the kind of information needed to enhance their efforts. Technical assistance programs, for example, might gain more awareness of how best to target their efforts to achieve maximum waste reduction in a State. A large proportion of the information gathered, however, might not be usable because of confidentiality concerns.

- Rather than initiating a Federal program, EPA could work with State and local governments to determine to what extent the gathering of such information by those agencies might be useful, and how such programs could be most effectively designed to meet particular State or local needs. If, eventually, a significant proportion of State and local governments decide that such information is of value, industry might prefer standardized data gathering at the national level. Standardization, however, still might not meet State- and county-specific needs.

8.6.2 Use of Permits to Limit Amount of Waste That Can Be Land Disposed, Incinerated, or Otherwise Disposed of or Treated per Generator

This is a variation on the preceding option ("Waste Generation Permit Program"), and many of the considerations developed there also apply to this option. It does not require permits for the generation of waste; rather, the permits would apply to the amount of waste that can be managed in certain ways. Thus, the generator is free to generate any amount of waste, but the limitations on waste management alternatives will force consideration of waste minimization measures.

The limitations on amounts of waste that may be disposed by any specific method would be on an annual basis. They could be based on some typical ratio of waste types and volumes to production for typical processes. It would be possible to set an initial baseline for the allocation, and then to shift the allocation over time from less desirable to more desirable disposal alternatives, as well as to require overall reductions. Such a waste management marketable permit system could either supplement, or be used instead of, the waste generation permit system in the previous option. It could also be used to supplement the land bans required under HSWA, by gradually reducing the total volumes of wastes permitted to be land disposed.

A company would be able to landfill (or incinerate, or otherwise treat) its permitted allotment in whatever time period it chose, so long as it did not exceed its annual apportionment. It would be possible to design such a system either with strict limits, which would apply on a nontransferable basis to each company, or with permits that could be sold or traded between plants. The primary benefit of a marketable permit is to increase flexibility and avoid the necessity of a waiver system for each facility with a slightly unusual waste management problem.

Observations:

- Such an approach, if implemented, could be used to encourage substantial reductions in the production of unrecyclable waste.
- In principle, it would be possible to allow a standard proportion of each type of waste produced by a company to be permitted for incineration, land disposal, or other treatment method. But in addition to the technical and administrative complexity of such an approach, such a strictly proportional allocation method would provide little or no incentive for waste minimization at the source. It would, however, encourage recycling of the wastes produced.
- Implementation of such limitations would allow allocation of waste disposal between allowable treatment and disposal methods according to ratios and criteria determined to be most acceptable on either a regional or national basis.
- If limitations were implemented on a plant-specific basis rather than on a regional basis, two problems could be avoided:
  - There would be no problem of new entrants, since each new entrant would automatically receive its own proportional allotment of disposal allowances, depending on the products and processes involved.
  - It would not be necessary to determine how to allocate the allowable total limits among facilities at the outset of implementation, since each facility would receive an allocation based on its past waste generation record, or on the basis of the type of facility.
- If permits were allocated on a geographical basis, all the equity difficulties related to original distribution and later entrants would arise.
- Even if developed on a plant-specific basis, however, there are significant informational and implementation problems:
  - There would be enormous practical difficulty, both administratively and technically, in establishing appropriate allocations of permits for the various treatment/disposal alternatives for different types of generators.
  - There would be substantial questions, with respect to both equity and feasibility, in determining whether to differentiate allocation rates on the basis of size, as well as type, of operation, in order to recognize scale efficiency problems both of unit operation size and company size.

- Instead of criteria based on the type of facility, allocations for each waste management or disposal method could be based on past waste generation records for each facility (as in the other marketable permits option, 8.5.2), and an arbitrary division of permits among the various waste management alternatives, based on national objectives. Trading of permits between facilities (in a permit market) would then be the method of reallocation to more closely match final allocation to actual facility needs. This could create some initial advantage for facilities with a lower proportion of wastes to be landfilled.

- The number of facilities for which permits would have to be determined on a generator-by-generator basis would require a substantial administrative effort.

- Some companies (especially smaller companies) may be unable to meet the permit limitations. If implemented with tradeable permits, the system would be flexible enough to allow for such less efficient operations. Still, finding permits for sale could be difficult, since companies might decide to retain excess permits until late in the year to ensure that their own wastes are covered. It may, therefore, be necessary for EPA to decide whether to close such less efficient facilities, to charge a fine high enough to discourage avoidable noncompliance, or to create special classes of exemptions for certain types and sizes of smaller facilities. The determination of appropriate exemptions or fines would require significant additional administrative effort.

- Companies already faced with the need to respond to the disposal limitations imposed in the 1984 amendments to RCRA are likely to find these additional, and far more complex, limitations especially burdensome.

- Further limitations on waste disposal could well be attractive to the concerned general public. But if tradeable permits are used, the general public might focus on the license-to-pollute appearance of the trades rather than on the inherent limitations provided for by the permits.

- The cost and complexity of meeting these requirements may discourage small quantity generators from compliance and lead to more illegal dumping.

8.6.3 Require Segregated Waste Streams for Potentially Recyclable Wastes

This option would ban the mixing of waste streams that are potentially recyclable. EPA could decide when waste stream segregation will be required on the basis of the same kinds of technology evaluations and economic analyses that are currently used to make the technology-based performance standard determinations under the Clean Air and Clean Water Acts. Internal or onsite recycling potential could be determined through industry analyses; information on what materials could be recycled offsite could be developed through industry analyses and data obtained through waste exchanges. While such a regulatory requirement might not specifically require recycling of the streams once they are segregated, it would make recycling more feasible by resulting in waste streams that are relatively uncontaminated (by virtue of not being a random mixture), and thus more amenable to subsequent recovery. In addition, the remaining (not recycled) segregated waste streams will often be easier and safer to treat and dispose of than would combined waste streams.

As discussed elsewhere in this report, there are a number of processes where the potential for recycling would be substantial if appropriate wastes were segregated. The following are examples:

- In the production of inorganic pigments, segregation and reuse of some of the wastewater streams are feasible. Rinsewater from equipment cleaning baths could be reused as process water during subsequent batch productions of the same product. "Strong acid" could be recovered and reused during production of titanium dioxide if impurities such as iron were removed. While much of the industry has already taken steps to segregate wastes (e.g., many producers of cadmium pigments practice wastewater segregation), significant additional reductions appear feasible. An inhibiting factor is the substantial investments already made in wastewater treatment facilities. (See Table 9-1 of Appendix B-5 of analysis on inorganic pigments.)

- In metal surface finishing, segregation of spent bath solution from rinsewater makes the recycling of the spent bath solution more feasible. In addition, segregation of the rinse streams from the various coating operations makes the reclamation of metals from each stream more practicable, as well as the recycle of the streams themselves. While there is currently some limited use of segregation, greater application potential exists. (See Table 9-1 of Appendix B-6 of analysis of metal surface finishing.)

- While disposal of containers and bags accounts for only a small fraction of the total waste from the manufacture of organic dyes and pigments, segregation of bags containing toxic materials from those containing nonhazardous substances, which is not frequently done, would decrease substantially the total volume of hazardous waste from this portion of the process. (See Table 9-1 of Appendix B-7 of analysis of organic dyes and pigments manufacture.)

- In the manufacture of printed circuit boards, segregation of the chelated waste streams (from catalyst application and electroless plating) from other metal-containing waste streams could prevent problems in precipitation and recovery of the metals. In spite of the general application of segregation of hazardous waste streams within the industry, separation of chelated waste streams generally is not done. (See Sections 9.1.2, 9.2, 9.3, and Table 9-1 of Appendix B-11.)

- Further examples of current or potential applications of waste stream segregation may be found in the analyses of paint manufacturing (Appendix B-8), petroleum refining (Appendix B-9), printing operations (Appendix B-12), wood preserving (Appendix B-18), paint application (Appendix B-21), and equipment cleaning (Appendix B-22).

Some solvent recyclers contacted for this study noted that, although some generators have improved their waste segregation efforts dramatically over the last few years as disposal costs have increased, many other generators -- even fairly large and otherwise sophisticated ones -- continue to do a poor job of segregation. A principal problem appears to be inadequate training of those responsible for the final steps of waste disposal.

Observations:

- Requiring segregation of wastes could lead to substantial increases in the volumes of wastes available for recycling. In some cases, sensitivity to purity requirements may inhibit use of recycled materials (see, for example, the discussion in the sections referred to above on printed circuit board manufacturing).
- Requiring the segregation of wastes would force generators to become more conscious of opportunities for recycling. A generator who undertakes the engineering and personnel training costs necessary to ensure segregation will be much more interested in recouping costs and reducing disposal expenses by trying to recycle wastes whenever possible.
- Requiring segregation of wastes could facilitate waste exchange efforts (such as that in Illinois) by expanding the market for purchase and sale of recyclable wastes.
- Even after a segregated waste stream has been determined to be "potentially recyclable," the recycling will depend on market, geographic, and technical factors, which are subject to substantial variability. In some cases, facilities and/or markets for recycling may be unavailable, while the costs of having segregated the waste streams may be substantial.
- Implementation and enforcement may require substantial resources.

- New prohibitions on land disposal and dramatically increased costs for all forms of disposal, coupled with substantial efforts to increase industry awareness of recycling possibilities, may provide adequate information and incentive for waste stream segregation without requiring such action by regulation.

8.6.4 Require Technical Audits to Identify Waste Reduction Potential

Firms could be required to carry out technical audits to identify possibilities for reduction and/or recycling of wastes. Information from such audits could be made available to EPA to determine whether generators are doing all that is possible to minimize wastes. Alternatively, firms might simply have to meet the auditing requirement, with the information retained for their own use, on the assumption that identification of opportunities for waste reduction (and elimination of product and/or raw material losses) would provide sufficient incentive for the firms to take corrective action.

EPA has chosen a voluntary approach to environmental auditing in its interim guidance (50 FR 46504, November 8, 1985): "Because environmental auditing systems have been widely adopted on a voluntary basis in the past, and because audit quality depends to a large degree upon genuine management commitment to the program and its objectives, auditing should remain a voluntary activity." A possible exception to this voluntary approach would be in enforcement actions "where auditing could provide a remedy for identified problems and reduce the likelihood of similar problems recurring in the future."

In addition, the Agency states in the interim guidance that it generally will not request reports on audits that firms carry out. "EPA believes routine Agency requests for audit reports could inhibit auditing in the long run, decreasing both the quantity and quality of audits conducted." On the other hand, the Agency may request reports "on a case-by-case basis where [it] determines it needs an audit report, or relevant portions of a report, to accomplish a statutory mission...."

Although the required audit option is not entirely in keeping with EPA's emphasis on voluntary audits, its scope is limited to an analysis of available waste minimization alternatives, rather than the full gamut of activities normally incorporated in an environmental auditing program.

Observations:

- Requiring such limited purpose and specific environmental audits would increase the attention of generators to the possibility of reducing or recycling waste streams. Whether, without any further requirements, facilities would take action on the waste minimization alternatives identified would depend primarily on the economic benefits and costs of the alternatives.
- Environmental audits of the type required for this option might provide EPA with more information on the use of processes and materials that would facilitate reduction or recycling of hazardous waste. But requiring technical audits for the specific purpose of identifying the potential for waste reduction or recycling could be an extremely cost- and time-intensive way to meet this objective.
- If the information gained from such audits were to be used for enforcement purposes rather than as a confidential internal management tool, it seems unlikely that generators concerned about legal liability would be hesitant to develop and use the audit as a real management tool. There would be considerable fear, dependent on the treatment of proprietary information, that such an audit requirement might effectively confiscate trade secrets.

8.6.5 Ban the Landfilling, Treatment, or Incineration of Potentially Recyclable Wastes

Under HSWA, specific hazardous wastes are banned from landfills, based on the threat to human health and the environment that continued use of such disposal practices would pose. The availability of alternative methods of waste management may be taken into account to a limited extent. This option expands the principle of banning inappropriate disposal of wastes by prohibiting the disposal, either through landfilling or other methods of disposal, of any waste that is potentially recyclable. A similar program is in place in California, and a related requirement is planned in Illinois. Under the California hazardous waste regulations, there is a list of wastes deemed to be recyclable. A generator who does not recycle such wastes must provide justification for the choice of waste management method.

The implementing regulation would be predicated on the development of a list of waste materials that are recyclable. Like the California rule, this regulation would allow an appeal procedure for generators who demonstrate that recycling would be technically or economically infeasible.

Observations:

- One of the major problems to be resolved to make such a requirement workable is the development of a market for recycled materials equal to the supply that could be created. One possible factor in the development of such a market could be the expansion of the current waste exchange system to include larger segments of the private secondary materials market, and the development of the capability for improved efficiency and responsiveness by waste exchanges (see discussion of waste exchanges, Section 4.3.2).
- If EPA could readily identify appropriate industries and waste streams, this approach would have the potential for substantially reducing disposal of wastes. But recyclability of nominally similar waste streams may differ because of variations in industrial processes and waste stream components, and such identification may be difficult.
- Implementation may be difficult, even for a limited program. California has made very little use of the mechanism requesting justification from generators for failure to recycle wastes considered recyclable by the State. The review of manifests to identify such opportunities has ceased to be actively pursued. More detailed examination of California's recycling program would be in order before deciding to adopt this regulatory approach.

8.7 Economic Incentives

8.7.1 Development of Information and Technology Transfer Network

EPA could undertake nonregulatory programs to assist in the development and exchange of information on waste reduction and recycling and to provide technical assistance to generators on how best to realize waste reduction goals. Alternatively, or in addition, EPA could play an increased role in facilitating the development of State programs through provision of technical assistance, funding, and/or central coordination. For funding and technical assistance for State programs, the question to be considered would be the extent to which increased support would achieve useful waste minimization results, since EPA already provides some support for specific State technical assistance efforts. Providing a central source of information for technical assistance, including coordination and dissemination of the results of various State activities, could involve a significantly expanded EPA effort with respect both to role and resources.

Several States have already developed a variety of information exchange and technology transfer programs to encourage and educate generators -- especially smaller generators -- to take the steps necessary for greater recycling and minimization of waste generation. At present, the most extensive State effort is North Carolina's Pollution Prevention Pays program. (See Section 7.4 for descriptions of general State programs; Appendix J-8 contains descriptions of North Carolina's program.)

Information Exchange

To facilitate the exchange of information, a central clearinghouse could be organized by EPA to track all available information on source reduction, reuse, and recycling. In addition, it would include successful results and examples produced through the on-going State technical assistance programs. A central library of information and an inquiry center could be maintained, and the information could be accessed directly by State agencies, generators, or the public. Several State agencies (e.g., New York, Illinois) are currently developing information centers of their own for use by generators in the State. The center could facilitate State efforts and make them more cost-effective. Information developed and gathered by the center also could be actively disseminated through agency publications, seminars, direct mailings, local educational programs, and the media, in coordination with State public education efforts.

To increase the awareness of the availability of such information, and the cost-effectiveness of waste minimization for generators, EPA could develop (or assist the States in developing) mass media advertising, contests, or awards to provide recognition and financial reward for waste minimization achievements, and mailings of information likely to be of specific interest directly to the generators.

If any of these efforts were to be done on a national basis (e.g., media), tag lines in each State with technical assistance programs could identify the appropriate State contacts.

For these efforts to be genuinely effective, the information center could not be passive. It would need to have a follow-up capacity to provide assistance in interpreting and utilizing the information and to link generators making such inquiries to the technical assistance programs to the appropriate State offices.

Numerous States, including Massachusetts, New York, North Carolina, and Pennsylvania, currently operate programs with substantial informational components (see Appendix J, Sections J.4, J.7, J.8, and J.9). Massachusetts, for example, has held several conferences and seminars directed at providing information that would lead to technology transfer on waste minimization. New York's Environmental Facilities Corporation will perform information searches for generators through its extensive data base on hazardous waste; the corporation also publishes a quarterly newsletter. There is substantial diversity in the range of services currently offered by various States.

Technical Assistance Programs

EPA could increase funding for State technical assistance programs. It could also provide an information center that could track the variety of efforts undertaken in such State programs, evaluate the success of those diverse efforts, and provide some analysis of the factors contributing to success or lack of it. In addition, EPA could rapidly disseminate among States the technical information developed through each of these programs, thus increasing the cost-effectiveness of individual State efforts.

Several States have developed direct technical assistance programs, most of them recently. These technical assistance programs involve both direct work with individual generators to assist them in determining how best to achieve waste minimization within their own facilities, and more generic efforts to find workable technological alternatives to advance waste minimization for the more important industrial groupings within the State. The technical assistance component of North Carolina's Pollution Prevention Pays program involves technical advice provided by phone or during onsite visits to plants. Comprehensive plant audits often take as much as a week, and review possibilities for changes in production materials, process modifications, waste stream segregation, and greater recycling and reuse of waste materials (either by the plant itself or through sales to other facilities). While the officials representing the North Carolina program cannot make specific recommendations, they do review with the generator the various options and their economic implications, including the costs and payback periods of purchasing any necessary capital equipment. They can also assist in finding consulting engineers who can help plan and manage waste minimization technical changes for the generator.

Several other States have begun programs with similar elements. In Minnesota, the State hires summer engineering interns who spend up to half of their time for ten weeks at an individual facility, assisting the generator in managing the identification and implementation of waste reduction alternatives and technologies. In still other States, technical assistance programs are managed through university centers such as those of the Georgia Institute of Technology and Penn State University. Many of these State programs receive at least partial funding from EPA.

Research and Development Linked to Informational and Technical Assistance Programs

EPA could expand funding of research and development efforts linked to State technical assistance programs. It could also, additionally or alternatively, provide coordination between on-going State efforts. There are numerous possible elements to such research and development components.

Illinois provides one example of a State R&D effort. It is starting its own research and development into waste minimization technologies and alternatives that might be used by generators in the State. This effort will be funded by a tax on land disposal of wastes. R&D elements in some States are primarily university-based, often partially Federally-funded. In Illinois, there are university-based R&D efforts at the University of Illinois and the Illinois Institute of Technology.

Some States provide incentives to companies to carry out development or implementation of new or innovative technologies in their own facilities. In Minnesota, generators or groups of generators may receive up to $30,000 from the State for new applications of existing technologies for waste minimization, or for research on untried methods. In North Carolina, the State will provide matching grants of up to $5,000 for new implementations of waste reduction technology; while these grants are primarily limited to small businesses, they are also available for larger companies to fund clearly transferable innovations.

Observations:

- While there is little hard evidence available, many believe that the initial impact of the various ingredients of State technical assistance programs has been substantial and positive, especially for small businesses. It is difficult, however, to assess the impact and evaluate the cost-benefit ratio for such programs, or to ascertain whether costs are high or low relative to the reductions achieved, particularly for the labor-intensive direct engineering assistance programs. Meaningful data may be difficult to generate until the State programs have a longer operating history.

- The savings possible through waste minimization are not always apparent to plant managers, but programs of this kind can make them aware of the benefits of reducing, reusing, and recycling their wastes.

- Even though such programs may be extremely cost-effective, start-up funds may be hard to come by, especially at the Federal level.

- Creating central information systems accessible to generators at the State level lowers the costs and increases the incentives for those generators who lack the engineering expertise or access to information to investigate alternative technology and management approaches to waste reduction and recycling. Even technical assistance in the form of referrals to consultants can help to reduce waste and industry costs.

- Creating a central information exchange at the Federal level would provide a means of facilitating the development of State information centers at the lowest overall cost, and expedite the rapid dissemination of information developed through technical assistance and research programs in one State to other States.

- Provision of engineering expertise in waste reduction by the States, whether directly or through university centers, fills a gap in expertise in industrial and chemical engineering, especially for smaller companies.

- Demonstration grants can assist in proving "paper" technology, and are therefore an extremely cost-effective form of R&D.

- Government funding of R&D ensures public access.

- Matching grants for R&D spread the costs for government and make possible R&D projects by firms that would not otherwise undertake them. But R&D expenditures still yield uncertain returns.

- The publicity generated by such programs makes the public aware of the environmental efforts of government, and simultaneously encourages nonadversarial, mutually beneficial contacts between government agencies and companies in the pursuit of environmental objectives.

- Winning challenge grants and other types of awards is the favorable kind of publicity that many firms will seek.

- Processes differ to such an extent within single industries that the kind of generic information available through clearinghouses or developed through demonstrations may have limited value.

- Confidentiality of production technology could become an issue, since effective outside assistance requires thorough knowledge of the process. The incentive for firms to develop innovations over which they will not retain proprietary control may be extremely limited.

- This may be a difficult program for which to find a home within EPA. The complexity of measuring results at the generator level may make it difficult to define and meet clear performance standards. This problem could be particularly difficult if EPA were to undertake as its major role the development of a central information exchange, with special emphasis on coordination of information and efforts among State programs.

8.7.2 Establish Preferred Procurement Practices

Government procurement practices could be changed to encourage: (1) additional recycling of waste materials in certain types of products, and (2) greater emphasis on waste minimization in the manufacture of particular products.

Where products could contain specified optimal percentages of recycled materials, one option would be to specify required levels; this option is the first discussed below. Where the objective is to change materials management practices in the manufacture of a product, even though the material characteristics of the end product are essentially indistinguishable, the problem is more complex; this is the second option discussed below.

Procurement Guidelines Based on Materials Content of Product

The purpose of a government procurement program focused on the materials content of products is to create additional demand for products made with relatively less harmful materials, or for products with a higher proportion of recycled materials. Such an effort may either involve direct requirements for or encouragement of Federal Government procurement of desirable products (as required by the 1984 RCRA amendments for recycled paper), or indirect encouragement of changed buying patterns by State and local governments and/or private businesses (as in the "buy quiet" program).

The most obvious places where such a policy could be effective would be where the government itself is a high-volume buyer and could change the economics of the marketplace strictly through its own behavior. There are fewer such areas, however, than might be anticipated. In the case of paper, for example, direct government procurement accounts for only two percent of paper purchases.

There are also indirect vehicles for influencing markets beyond the governmental market. In the case of paper, for example, the State government program in Maryland requiring the purchase of increasingly large percentages of recycled paper has had the effect, over several years, of creating enough demand for recycled paper that it is no longer a high-priced specialty product for the State, and now actually costs the State slightly less than paper made with virgin stock. This could lead gradually to increased use of paper from recycled stock by private industry in the State, creating increasing cost reductions resulting from better economies of scale.

Examples of areas in which revised procurement guidelines for product content specifications might be explored are the more limited use of cadmium-plating on products that do not require its material qualities, the substitution of high-impact rubber for chrome on bumpers for government-fleet automobiles, the purchase of paints with less toxic fungicides and mildewicides, and the use of less toxic wood preservatives.

There are a number of possible options for encouraging recycling or the use of less toxic materials (or materials that leave less toxic wastes after manufacture or processing) through procurement policies. They include:

1. Direct Federal Government procurement guidelines or regulations, such as the EPA guidelines recommending purchase of cement or concrete containing fly ash, or as mandated by RCRA for paper (see Section 6002 of RCRA).

2. EPA promotion of specific types of guidelines for use by State and local governments and/or private businesses, as in the "buy quiet" program. In the case of the "buy quiet" program, many local governments incorporated noise standards into their procurement operations, granting points in procurement competitions for quieter machines, or setting minimal noise-reduction standards.

3. Establishment of an EPA information center for encouraging changes in State, local, or private procurement. With respect to private procurement, this would be of use primarily where there would be a clear cost-savings to business.

4. Development of a cooperative arrangement with the Department of Defense, since DOD has the largest procurement operation of any single source in the country. EPA might work with DOD (perhaps formalized through a Memorandum of Understanding) to assist in identifying both opportunities for, and management approaches to enhance the effectiveness of, appropriate modifications in selected procurement standards on an ongoing basis.

Observations:

- Where the Federal market leverage is proportionately large, either in total percentage of product purchases or on a scale adequate to affect pricing, the advantages of direct Federal procurement guidelines or regulations could be substantial. Direct Federal procurement will often not be of adequate dimensions to change the market significantly, however.

- EPA promotion of guidelines for State and local governments has the advantage of potentially affecting decisions involving a larger percentage of purchases than those involving the Federal Government alone. The success of the EPA collaboration with State and local governments in the "buy quiet" program illustrates the potential. Because of the resource-intensive nature of such an education and information effort, it probably would be most fruitful to focus on materials where it has been determined that a Federal procurement guideline or regulation is necessary, or at least for materials where the approach and objectives are readily understandable.

- Changes in procurement practices under which a single large buyer such as the military changed its procurement practices to encourage waste minimization (for example, by changing military specifications to allow for the use of recycled solvents for operations and processes not requiring pure virgin solvents) could have a significant impact on waste reduction in some areas.
- It will often be difficult to determine (or to achieve agreement among responsible parties) exactly what qualities in a product are necessary if the product is to serve its function safely and effectively, and yet that determination is essential for substitutions to be feasible. Some attempted substitutions of alternative platings for cadmium on a pilot basis on moderately sensitive uses have not been notably successful (see discussion of product substitution for electroplating, Appendix B-3).
- Cost savings alone will not necessarily persuade private businesses to substitute less toxic or recycled materials, even if product quality appears unchanged, if they fear their major commercial customers would be concerned by any alteration.

Procurement Guidelines Based on Process Used

The procurement guidelines to be considered here involve a more difficult problem than those in the preceding section. The objective is to create a preference for purchase of products which, though essentially identical in material characteristics to a competitor's products, are manufactured with processes that minimize the volume and/or toxicity of wastes. For example, a manufacturer could produce a product and practice waste segregation at its facility. Although the practice of waste segregation would not alter the quality of the final product being manufactured, it would contribute to minimizing wastes, and thereby qualify the manufacturer for favorable procurement consideration.

Since specifications of products for procurement usually focus on the characteristics of the product and not the processes by which they are manufactured, there might be both legal and procedural difficulty in trying to incorporate process waste minimization requirements directly into procurement guidelines.

One of the qualifications on which procurement for such products could be based would be a voluntary agreement by the manufacturer to certify to the purchasing agency that a waste minimization program has been instituted at its facility, and that this should be made a part of the contract with the purchasing agency. The certification statement could be the same as that required on manifests under HSWA, and would certify that such a program is instituted to the degree that is economically practicable. One major difference, however, would be that the contract would allow the purchasing agency to check to see that such a program were indeed being carried out.

The voluntary agreement to submit to the requirement of certification as part of the purchasing contract would not guarantee procurement. It would only be one of the factors to be weighed by the purchasing agency. Cost and performance or quality criteria would still be the most critical factors. In a tight competitive market, products for which the manufacturer submits to such a voluntary agreement might have an advantage. Also, since there would be no legal requirement to make such an agreement, firms that do not participate would not necessarily be eliminated from competition.

In order for such a program to be effective, however, there would need to be a method to ensure that waste minimization was indeed instituted at the facility. One approach would be an environmental audit conducted by the purchasing agency or by auditors hired by the agency for all applicable purchasing contracts. The installation of an auditing function would require a substantial commitment of time and resources in an area in which few agencies have experience. Unless such a function were already instituted within an agency, it is unlikely that many would be willing to commit to such an investment.

Such an auditing mechanism does exist within DOD; thus, this option is more viable for that agency than for those that would have to develop the auditing function. The Defense Contract Administrative Services Regions (DCASR), which reports to the Defense Contract Audit Agency, performs this auditing function for DOD. Briefly, it ensures that product quality control, as well as contract conditions, is being met. The audit teams may receive training by specialists, depending on the nature of what is to be examined. Thus, this option, if implemented by DOD, could entail training in environmental auditing, with special emphasis on waste minimization practices for the particular industry being audited.

This raises the question of what criteria would be used to judge whether a practice qualifies as waste minimization. As mentioned in Section 5.5.1, the legislative history of HSWA makes clear that EPA is not to prescribe standards or guidelines for waste minimization. On the other hand, it may be possible for EPA to cooperate with DOD in establishing guidance and standards. Such standards would then be limited only to those companies voluntarily agreeing to a condition in their contract requiring them to certify that they have instituted a waste minimization program. Failure to meet the guidelines or standards would not result in any EPA enforcement actions; rather, it would remove them from consideration for any established special procurement consideration.

Observations:

- Initial targeting of products for such a waste minimization procurement strategy would be most effective for products purchased in fairly substantial volumes, and for which waste minimization practices are well documented or studied. For example, the DOD (for whom this option appears to be most suited at this time) is a large purchaser of printed circuit boards, which are purchased from various manufacturing contractors. (See Appendix B-11 for further information on printed circuit boards.)

- DOD's current auditing function, carried out by DCASR, is motivated by a concern for product quality and proper contractual management (pricing, hours, and related issues). The ultimate quality of the product would be unaffected by waste minimization practices. At this time, the purchasing officer would probably not give consideration or special weighting to manufacturers who voluntarily agree to submit to contractual agreements that require them to certify that they are enlisting waste minimization practices. There is the possibility, however, that the various environmental channels within DOD (e.g., Defense Environmental Leadership Project, the Defense Logistics Agency, and the environmental divisions of the services) may be able to promote the idea to purchasing officers. Since DOD is developing a waste minimization strategy (see Section 7.3.3 for more information), part of that strategy could include adoption of this option by purchasing officers, with cooperation between the DCASR and EPA. In particular, the Air Force Systems Command (AFSC) currently is retaining a consulting firm to evaluate the operations of its government-owned, contractor-operated industrial plants. The firm is to evaluate the operations of these plants and to recommend alternatives for waste minimization. The AFSC anticipated initiating actions during FY 1986 to implement study recommendations (see Appendix I, Briefing Synopsis of JLC).

- Because this option is based on voluntary agreement to submit to contractual requirements to verify that waste minimization is taking place, it will be very difficult to get the relevant bureaucracy to incorporate such considerations in actual procurement decisions without the force of legislation.

- It is not clear how great the DOD market share may be for products with respect to whether this option would have any appreciable effect on industry practice.

- One key ingredient to the successful operation of this option is the development of waste minimization guidelines and/or standards that the auditors could use. It is not clear to what extent they could be developed or accepted by industry. If guidance is developed and consideration of voluntary agreements is included in purchasing decisions, this could create a growing incentive over time for companies that compete in the DOD marketplace to adopt waste minimization practices. The success of such a purchasing program may increase its use over time and could be implemented by agencies other than DOD.

- EPA may be able to play a role in developing this option. EPA's role might be to create a model for its implementation, and to bring together and encourage some of the parties who could be most usefully involved in a pilot effort. EPA's involvement, however, is contingent upon the degree to which it agrees to develop waste minimization guidance. It is not clear whether EPA's involvement in developing such guidance may be construed to be in opposition to the intent of Congress in its requirements for waste minimization. The legislative history indicates that EPA is not to intrude in nor interfere with the production process, and that determinations of technical and economical practicability of waste minimization practices are in the domain of the generator, not EPA. Thus, EPA's role may be subject to debate both within and outside the Agency.

8.7.3 Develop Improved Waste Marketing Capability for Hazardous Wastes of the Military Services

Included in the enormous volume of hazardous wastes generated by the facilities of the Department of Defense (the nation's largest hazardous waste generator) are a substantial proportion of wastes that could be reused or reclaimed. While some of these wastes are currently recycled both within and outside of the services (e.g., outdated paints from the Norfolk base are bought and used in substantial quantities by Virginia, Wisconsin, and other State and local governments), the opportunities for recycling could be substantially expanded. (See Section 7.3.3 for a description of DOD waste minimization efforts and Appendix I. For information on waste exchanges, see Section 4.3.2.)

A central DOD waste exchange service would be able to expand the scope of recycling by DOD facilities, both by interfacing with the industrial markets (perhaps working with existing regional waste exchanges) and by expanding the reuse and reclamation of hazardous wastes within the services.

To facilitate the creation of such a waste exchange capability, and to provide DOD with the technical and market information available to EPA, DOD and EPA could develop a memorandum of understanding under which the Department and the Agency would work together to plan for and to implement such a waste exchange capability. The waste exchange service would be housed in the appropriate office of the Department of Defense.

Observations:

- Creating such an exchange could open substantial new markets for recyclable hazardous wastes from the military services, and thereby reduce substantially the wastes sent for disposal.
- By creating a financial return instead of a loss for some segment of hazardous waste disposal, such an exchange might make more acceptable to the Services a change (previously rejected both by the Services and by the Defense Logistics Agency) under which the costs of disposal would be allocated to the base of origin for the waste, rather than being provided as a free service by the Defense Reutilization and Marketing Service (formerly the Defense Property Disposal Service).
- Such an initiative might contribute to efforts to change DOD's procurement practices to include greater emphasis on recyclable materials.
- For some industries and/or geographical areas, the greater availability of reclaimable or reusable materials might provide a lower cost alternative to virgin materials.

8.7.4 Non-Tax Financial Incentives

Direct loans, defrayal of loan interest, loan guarantees, or bond issues could be used to provide direct financial support to generators for installation of equipment for reducing or recycling hazardous wastes. The effectiveness of such programs could be enhanced by linking them with informational and technical assistance programs. (For discussion of current State loan and bond programs, see Section 7.4.3. Other non-tax financial incentives, though not so generally available to generators or specifically tailored to include equipment purchases, are the awards and grants provided as part of the technical assistance programs. See the summary of State programs, Section 7.4, and the option (8.7.1) discussing such programs.)

Given the current status of the Federal budget, the establishment of any new loan programs seems extremely improbable. Even the continued availability of funding by means of industrial development bonds is uncertain in current tax legislation. It would be possible, however, for EPA to assist the States in designing effective non-tax financial assistance programs. There is a great deal of variety in current State financial incentive programs, and EPA could assist in an informational and analytic capacity in reviewing these State efforts and their results.

Funds for loans or loan guarantees for pollution control, waste reduction, or recycling facilities could be directly appropriated on an annual basis, with receipts from repayments returned to the State treasury. Alternatively, directly appropriated funds could be repaid to a revolving fund, which would be supplemented with further direct appropriations only as necessary. Several States, however, have linked together bond and loan programs, eliminating the need for direct appropriations (though the nature of bond-financed programs in the future may depend on revisions made in the Federal tax code). New York's Environmental Facilities Corporation, for example, uses funds raised from special obligation revenue bonds to provide loans for up to 40 years for investment in pollution control and waste minimization equipment, with no ceiling on the amount. Missouri provides greater access to the loan market for such projects through a revolving fund that is used as collateral for the purchase of loan insurance (increasing both availability of funds and attractiveness of interest rates). Such a revolving fund provides very high leverage with limited funds. Availability of funds from such programs is often limited to small businesses.

Observations:

- Availability of loans, or reduced interest on loans, can be a factor in the affordability of new equipment for many small generators. It is not clear exactly, however, what the impact of such programs is on waste reduction activities, since other factors such as productivity and product-specification requirements are major influences on investment decisions

- An important factor in designing such a program is the criteria for deciding which projects are eligible. One way would be to provide eligibility only for investments undertaken strictly in order to reduce or recycle wastes. Another option would be to provide financial support as well to any investment that will result in some waste reduction or reuse, even if its main purpose is productivity- or quality-related. If access to funds is to be limited to single-purpose investments in waste minimization, eligibility determinations may become a major obstacle, and ancillary waste reduction opportunities might be lost. A broad interpretation of purpose, however, might dilute such a program's objective by providing loans for investments in production-related equipment with limited environmental benefits.

- To the extent that eligibility determination must be made, the demands on technical staff for verification of eligibility could be substantial.

- To be most effective, loan programs should be an integral part of a comprehensive information and technical assistance program. Otherwise, generators may not take advantage of the programs because they are not aware of them.

- The practices of the larger generators are unlikely to be significantly affected by most State loan programs, since the financial benefits are relatively small.

- EPA could serve a useful role for the States by providing a central source of information on the design of various State loan programs, and by analyzing their effect.

8.7.5 Tax Incentives

There are a number of tax and tax-credit options, in addition to the waste-end tax discussed in 8.7.6, that could provide economic incentives for waste generating firms to implement source reduction measures, or reduce incentives for use of virgin materials in preference to equivalent recycled materials. (For discussion of State fee and tax incentives, see Section 7.4.2.) While some of these (such as elimination of depletion credits for raw materials) could be enacted at the Federal level, the most feasible role for EPA might be to provide analytic support and review of State efforts.

- Waste use taxes: These are intended to induce water conservation, and could lead to reductions in water use, and corresponding reductions in generation of large-volume aqueous waste streams (such as corrosive characteristic wastes (D002)). Such taxes are common at the State or local level, although the rates for industrial users may not be designed to discourage use and encourage alternative waste control strategies.

- Capital investment tax credits and deductions: Tax credits could be targeted on investments in equipment used to reduce or recycle wastes. In Minnesota, for example, there is a 10 percent credit for the net cost of waste processing equipment and a 5 percent credit for the net cost of pollution control equipment. In Wisconsin, the cost of investment in pollution treatment equipment is 100 percent deductible.

- Tax exemptions: Exemptions from taxes that would normally be levied on capital equipment could be provided for equipment used to reduce or recycle wastes. A strategy of this kind, currently used in Wisconsin, provides an exemption from property taxes for equipment used to treat industrial wastes that would otherwise contaminate surface waters. Minnesota provides an exemption from sales taxes for waste processing or pollution control equipment.

- Accelerated depreciation: Many States allow faster depreciation on capital equipment for pollution control or waste minimization than on most other classes of capital equipment. The depreciation is taken as a deduction.

- Tax credits for waste reduction: Credits against various taxes could be provided for measured declines in waste generation. Such credits would not be linked to capital investments in equipment. A schedule of credits tied to specific quantities of waste reduction would have to be developed.

- Elimination of special tax benefits for raw materials: Reduction or elimination of the various depletion allowances and other special tax benefits for production of raw materials would make reclamation and reuse of materials from waste streams more financially competitive and attractive.

Combinations of tax incentives may be useful to provide the necessary encouragement to generators to invest in waste minimization. As noted above, for example, Minnesota provides both investment tax credits and exemptions from the sales tax for investments in waste processing or pollution control equipment, while Wisconsin offers tax deductions and an exemption from the property tax for equipment to treat industrial wastes.

Observations:

- Different tax incentives, or combinations of tax incentives, could affect different aspects of generator activity. The water use tax, for example, is obviously more useful for aqueous than for nonaqueous wastes.
- Tax incentives should not be looked at in isolation. They are part of an overall system of incentives, which include non-tax financial incentives and technical and informational assistance.
- The benefits of any tax incentive have to be substantial enough for people to participate, or to encourage them to overcome other obstacles to investments in waste minimization reduction. In California, a tax credit was a significant factor in enabling metal finishers to meet pretreatment standards (personal communication with Mr. Bill Wiggins, President, Automation Plating, Glendale, Calif., September 30, 1985). In Oregon, on the other hand, very few firms have taken advantage of a tax credit for investment in reclamation equipment, which deducts from the credit any financial return gained from the investment. Its unpopularity is due to the fact that many resource recovery investments result either in a very limited net loss or in a net profit (personal communication with Bob Brown, Hazardous and Solid Waste Division, Oregon Dept. of Environmental Quality, July 12, 1985). An IRS ruling provided that special depreciation rules for pollution control equipment (which have now been rescinded) could only be used if the equipment had no benefit other than pollution control. This provision virtually eliminated the utility of the benefit.
- Restrictions on tax benefits that limit their use to investment with no net returns may not adequately take into account the cash flow limitations of smaller generators. Even though a resource recovery investment may eventually be fully recovered, a tax incentive may be required to make it feasible for the generator to make the initial investment.
- It would be advantageous to link tax benefits with a technical and informational assistance program, so that generators are both aware of the possible waste reduction and recycling investments they could make, and of the tax benefits to make them more feasible.
- Accelerated depreciation can provide a major benefit to large corporations, which can take full benefit of the tax deduction involved, though it may be of limited value to smaller firms.
- While credits for actually-measured waste reduction have the benefit of being targeted on actual accomplishments, determining the baseline and actual level of reductions is likely to prove complex.

8.7.6 Waste-End Tax

A waste-end tax is a tax assessed at some point in the management of hazardous waste. In addition to any waste-end tax passed by Congress during amendments to the Comprehensive Environmental Response, Compensation and Liability Act, EPA could provide a service to the States by providing information on alternative waste-end tax structures, and an on-going analysis of the effects of these alternatives on waste reduction, reuse, and recycling, as well as on State revenues (for a discussion of current State waste-end taxes, see Section 7.4.2). This would provide a better information base for the States to use in making decisions in light of their own objectives.

Depending on the type of waste-end tax, and the point in the waste management system where it is applied, a waste-end tax can be used to create incentives for reduction in waste generation and/or for preferred waste management practices.

There are three basic points in the hazardous waste management chain where a waste-end tax can be assessed. These are the point of hazardous waste generation, the act of hazardous waste transport, and the point of hazardous waste management. A generator tax is a tax on companies that produce hazardous waste. If "generator" is defined by the RCRA system, certain exemptions would apply, the most notable being the small quantity exemption. A transporter tax would be assessed on those who move hazardous waste from the point of generation to a facility or from a storage treatment facility to a disposal facility. A facility tax would apply to storage, treatment, and disposal facilities. If the RCRA system is used, certain facilities may be exempt from a facility tax (e.g., generators that store hazardous waste for fewer than 90 days, or generators that use pretreatment facilities prior to discharge to a POTW).

There are a number of options in the type of waste-end tax or fee that is assessed. These can be broken down into the following categories of taxes: a flat rate, a rate graded by type of management, a rate graded by degree of hazard, a surcharge or tipping fee, a permit or manifest fee, or any combination of the above.

1. Flat rate. This is a flat tax on a per-ton, per-gallon, or per-barrel basis.

2. Rate graded by type of management. This is a tax rate that varies depending on the type of facility to which the waste will be sent. For example, a graded tax rate might place a higher rate on land disposal facilities and a lower rate on resource recovery facilities. New York charges $12/ton for land disposal and only $2/ton for onsite incineration (GAO 1984). In other instances, a State might charge for land disposal exclusively and levy no fee on other forms of treatment or disposal. Missouri, for example, levies a $25/ton fee on wastes that are land disposed. It is designed to encourage/discourage certain forms of hazardous waste management.

3. Rate graded by degree of hazard. The tax rate is based on the hazardous characteristics of the waste (usually toxicity). The more hazardous the waste, the higher the tax.

4. Surcharge/tipping fee. The tax is a surcharge based on the value of managing the waste. In some States, such as Ohio, facilities act as "an agent of the State," collecting a surcharge on all waste received at the facility and paying it to the State. The rate in Ohio is 6 percent of the charge paid to the facility for hazardous waste disposal.

5. Permit or manifest fee. A fee is charged to an application for a hazardous waste permit or is assessed on the basis of the manifests required by RCRA.

It would also be possible to charge a tax based on the total volume, or toxicity-weighted volume, of all hazardous material inputs that are neither incorporated in the product nor used up in a chemical reaction (i.e., on all materials discharged, emitted, or disposed of). A credit against the tax could be given for recycled materials.

Finally, any combination of these taxes could be used. The State of Washington, for example, has risk classes for both generators and treatment/disposal facilities based on the type of waste management/disposal practiced, and the degree of hazard of the waste streams generated or managed.

As of December 1983, 34 States had set up their own "Superfunds" to address problems related to emergency cleanup and abandoned sites. Of these States, 23 adopted waste-end taxes in some form, 8 utilized flat rates, 7 graded the fee by type of hazardous waste management activity, and 7 used revenues from permit or transfer fees. Grading by degree-of-hazard and surcharges or tipping fees were only utilized in 4 States each.

In all cases, revenue was the primary goal of the funding mechanism. Revenue needs are usually estimated and the tax rates developed to achieve that goal. Incentives, however, are built into some systems, particularly those that grade their taxes based on waste management type. Use of the RCRA definitions for generator taxes also works to create incentives for recycling through RCRA's exemptions for this practice.

With respect to revenue generation as the goal of this type of tax, CBO (1985) has stated that such a goal is in conflict with that of waste reduction. (See Section 7.4.2). They suggest elimination of this conflict if proceeds from the tax were placed in a fund dedicated to grants for projects that promote waste minimization. Such a fund would need to be only as large as the demand for such projects. As the projects were implemented, wastes would decrease and the fund would diminish.

Observations:

- A waste-end tax imposes the cost of cleaning up spills and abandoned sites on the industry that produces and/or manages this hazardous waste. It may also create economic incentives to encourage proper hazardous waste management. At exactly what level this incentive works is less certain. One study (Haas 1984) noted that the difference in cost/ton for the lowest cost disposal alternative (landfill or impoundment) and the next best for a variety of different wastes ranged from as little as $5.89/ton (for corrosive lead wastes using vacuum filtration) to as much as $1,075.52/ton (for incineration of small volumes of formaldehyde). It concluded that shifts in waste management practices because of fixed waste-end taxes would vary across industry classes and types of waste streams.

- A generator's tax will cover a comparatively large population and will establish economic incentives discouraging waste generation. A transfer tax (although adding to the cost of hazardous waste management) will discourage the transport of hazardous waste.

- Taxes on facilities will discourage certain types of hazardous waste management. For example, a degree-of-hazard tax on disposal facilities will usually be designed to discourage land disposal of highly toxic wastes. Lower taxes or tax incentives can also be used to encourage certain forms of hazardous waste management (recycling, treatment, incineration).

- In theory, the tax schedule could be set high enough to cause considerable waste minimization. In practice, States are unwilling to agree to such a system because the revenue is needed for their "Superfund" activities. A successful waste minimization/recycling program jeopardizes funding for these other activities. (If Congress were to relax the Federal preemption language of CERCLA during reauthorization, States might be able to move to feedstock taxes and use waste-end taxes solely as an incentive mechanism.)

- Using the waste-end tax as a revenue generator may result in conflict with the goal of reducing wastes for reasons discussed above. CBO's proposal (CBO 1985) to use the tax to fund a grant program that promotes waste minimization may alleviate the conflict in goals and may also serve to combine several incentive programs productively.

8.7.7 Rating Outstanding Recycling Facility Performance

One possible approach to strengthening both the marketability and insurability of offsite recycling operations might be to develop a voluntary certification system for recyclers, through a consensus process involving representatives of all concerned parties (recyclers, generators, insurers, and governmental and independent experts). This would involve the creation of a rating committee that would issue to a recycling firm, meeting an extremely high standard of management and performance, a certification of the high quality of its operations.

Such a certification could be advantageous to the firm's marketing efforts by alleviating some of the uncertainty faced by generators trying to determine whether to use an offsite recycler. It might also be of benefit to recyclers seeking environmental liability insurance in the current shrinking insurance market.

The appropriate vehicle for determining the basis for such certification would be an organization that is involved in voluntary standard-setting, such as ASTM (formerly called the American Society of Testing and Materials) or the National Fire Protection Association. ASTM, for example, is a nonprofit organization specializing in the development of voluntary consensus technical standards, test methods, service methods, and performance standards. Membership on ASTM's technical committees (over 150) and subcommittees is voluntary, but all committees must have at least as many representatives of nonproducer as of producer interests. A clear majority of participants must approve the standard, and an effort is always made to consider and accommodate the concerns of all participants.

The consensus standards established through such a process would be voluntary in operation (although the market pressures for a recycler to meet such standards, once developed, would be substantial). Actual determinations of whether individual recyclers meet the standards could be made by approved third-party auditors. EPA's role would be to help initiate the process with an appropriate standard-setting organization, to assist in exploring whether adequate interest exists among interested parties to support the development of such certification standards, and to provide staff support to the effort.

Many generators with reclaimable materials are uncomfortable with the prospect of using offsite recyclers to handle their wastes because of the danger of long-term liability. As a result, some firms may prefer, where possible, to dispose of materials onsite rather than recycling offsite.

There are, of course, existing mechanisms through which generators could obtain some information on the quality of operation of a recycling facility, in order to reduce the level of uncertainty. The large and sophisticated generator frequently does its own audit of the recycling firm and its operations. For generators lacking substantial technical and financial resources, however, this is not usually feasible. They could contact other generators to learn something of the recycler's reputation, contact the State agency to determine whether there were any present or past enforcement actions against the generator, and do a walk-through of the facility to try to detect any obvious bad management practices. Nonetheless, a firm without the capacity to run its own audit on the generator may still find itself with substantial uncertainty with respect to a decision that could involve substantial long-term financial risk. The certification procedure outlined above is designed to meet the generators' concerns.

Observations:

- Many generators who would otherwise choose methods involving less waste minimization might choose to use a certified recycler, thus increasing the rate of recycling.

- A recycler meeting the certification standards would have a competitive advantage over recyclers failing to meet that standard. The result might be a major market incentive and market reward for those recyclers with the most environmentally sound operations. Some of the recyclers contacted during this study felt that unless recycling facilities were able to satisfy standards more stringent than those imposed under RCRA, they were unlikely to go out of business. This was not a unanimous view, however, and many recyclers might be very reluctant to participate in such a voluntary standard-setting process. Some recyclers indicated that it would not be possible to meet any standards stricter or additional to those already necessary for Part B permitting, while still others asserted that there were no significant market problems for recyclers.

- Recyclers meeting such standards might have greater access to the dwindling supply of environmental liability insurance.

- Establishing such standards might be a long and difficult process, even with the enthusiastic participation of the recycling industry.

- While the involvement of insurers in the process would seem to be a primary attraction for the recyclers, there might be little incentive for the insurers to commit themselves to treat certified companies any differently from companies currently holding environmental liability insurance. Even if access to insurance were improved, the cost of insurance might not be.

8.7.8 Reduced Liability for Generators Using Specially Permitted Recyclers

The objective of this option would be to encourage recycling by shifting liability for wastes sent to specially certified recycling facilities from the generator to the recycler. To be certified, the recycling facilities would have to meet stringent management, operational, and financial standards beyond those otherwise required for TSD facilities. Generators would be willing to use such facilities for recycling their wastes, because they would no longer need to be concerned about future liability resulting from failure of the recycling facility to safely manage the wastes sent to them. To make such an option possible, legislative changes would be required that would exclude the future application of the strict, joint, and several liability provisions of CERCLA to generators for those wastes sent to such specially-certified facilities. (For a discussion of liability concerns raised by CERCLA, see Section 5.2 on liability and insurance.) This would be one possible way of breaking the "chain of liability," which some industry sources feel severely limits the recycling of potentially recoverable and reusable materials (see, generally, Section 5.3 on Attitudinal and Organization aspects).

Assuming it is possible to develop certification standards that are (1) feasible to meet and (2) adequately protective of health and the environment, how much impact such a change would have would depend significantly on the scope of applicability of the exclusion. Such a provision could either generally apply to any wastes sent for recovery to a certified facility or could be narrowly restricted to specific types of wastes (e.g., those with significant economic value) or wastes recovered for particular purposes or under specific contractual arrangements (e.g., batch tolling).

It would be necessary to establish a separate classification of recycling facilities that would be specially certified for this purpose. Minimally, three requirements would have to be met:

1. The facilities would have to be dedicated to resource recovery. The State of California has established a separate category of "resource recovery facility," which refers to "an offsite hazardous waste facility whose principal method of hazardous waste management is the handling, recycling, treatment, use or reuse of recyclable material." To qualify, a facility must recycle at least 50 percent of the hazardous waste it receives. It might be desirable to require a substantially higher recycling rate for the purpose under consideration in this option. (See discussion of California's Resource Recovery Facility Permits in Section 7.4.1 and Appendix J-1.)

2. Such a facility would have to meet exceptionally high standards of performance in its operations in order to obtain certification. Beyond standard inspections, it probably would be desirable to require regular environmental audits of both the facility and its management system to determine continued adherence to whatever standards are required.

3. Since one of the keys to transferring liability would be adequate assurance that any resulting liability could still be met, it would be necessary for such a facility to pass financial tests indicating a more substantial degree of financial stability and insurance protection, both long-term and short-term, than is otherwise required of TSD facilities (under CFR 264, Subtitle H).

Observations:

- Breaking the chain of liability for generators in this fashion should encourage generators to recycle materials they might otherwise dispose of even though the wastes might be recyclable. This option might have the environmental benefit of preferentially directing recycling to facilities with especially sound operating and management practices.

- While possibly facilitating recycling, this approach could create a disincentive for reduction of hazardous wastes at the source insofar as the driving motive for such source reduction is risk of future liability.

- The costs for a recycler of meeting any additional requirements for such certification could be substantial. Since these costs would then be passed along to the generators using these facilities, it could be the case that the smaller generators, who might benefit most from such a facility, would be least able to afford it.

- Adequate technical requirements for certification could be difficult to determine, and the procedure for certification could be burdensome administratively, even if the technical difficulties could be resolved.

- Sufficient financial standards would be difficult to ascertain (just as it is difficult for insurers to determine the risk involved in offering coverage for long-term environmental liability), and could be prohibitive for a facility to meet.

8.7.9 Recycling Substances Act

A Recycled Substances Act could provide legislative encouragement for recycling a variety of materials deemed to have significant economic value, which would be similar to the incentive provided for recycling used oil in the Used Oil Recycling Act of 1980.

Section 3014 (a) of RCRA requires EPA to regulate recycled oil. It requires EPA to analyze the economic effect of the regulations on the oil recycling industry. Of particular importance is the requirement that any such regulations "do not discourage the recovery or recycling of used oil," provided that adequate safeguards are written to protect human health and the environment.

This section of RCRA also makes clear that used oil listed as a hazardous waste, is not subject to any manifest requirement or any associated recordkeeping and reporting requirement with respect to such used oil, provided specific conditions are met (Section 3014(b)(2)(B)). These conditions are:

- Used oil must be delivered to recycling facilities that have valid permits under Section 3005;

- Used oil recycled by the generator must be at facilities permitted under Section 3005;

- Used oil must be mixed by the generator with other types of hazardous wastes; and
- The generator must keep records of agreements for the delivery of used oil to recycling facilities.

Presumably, the rationale is that the recycling practices of used oil are generally well-known, except for those instances when it has been mixed with hazardous wastes. In those cases, the exemptions would not apply. Also, the "well-known" aspect of used oil recycling includes a knowledge of general methods of recycling and recovery. Apparently, the recycling methods are accepted enough that delivery to a permitted facility ensures a sufficient degree of protection to human health and the environment.

A statute similar to RCRA's regulation for recycled oil also may be desirable for certain other classes of recycled substances. The substances to which such a law would extend could include those materials that, like used oil, also have the attribute of a "known quantity" about them. Such substances may include solvents leased under arrangements with companies that supply fresh solvent and recycle the spent solvent at permitted central facilities. Other batch-tolling arrangements for a variety of substances may also apply.

Observations:

- Such legislation would encourage an approach to recyclable materials recognizing their economic value, and recognizing the value of substituting recycled wastes for the production of virgin toxic materials.
- This option would encourage a regulatory approach focused more on recycling, and would promote the identification and favorable treatment of other commodities that are economically beneficial. It is difficult to predict, however, how substantial the economic impact would be for a generic requirement that does not specify particular substances. This is because the variety of substances and their uses covers a wide range and a general formula for economic effects is not possible to derive.
- This option would result in the relaxation of some of the regulatory requirements for hazardous wastes and generally could create an increased risk of sham operations and illegal dumping.

- The requirements of Section 241 of the 1984 HSWA amendments that EPA look more carefully at the risks posed by used oil indicate increased concern about loopholes in the regulatory process under which any classes of substances or operators would escape examination.

8.7.10 Expedited Consideration of Delisting Petitions

Wastes that are residuals from reclamation processes could be granted priority in review and action on delisting petitions. Since this would involve only internal setting of priorities, it would not require the drafting of regulations for implementation (see Section 5.5.7 for a discussion of the delisting process). If the approach of setting specific toxicity limits for hazardous wastes and constituents (see Section 8.5.1 for a discussion of that option) were adopted, such expedited evaluation of delisting petitions from reclamation processes would presumably not be necessary.

Observations:

- Expedited consideration of delisting petitions could create an incentive for reclamation, and would not require the massive analytical effort needed for setting automatic toxicity limits for delisting petitions. Generators with petitions for other wastes might object to such a priority, however.
- While providing for more rapid consideration of those petitions that are submitted for reclamation residuals, this would not provide as clear a set of guidelines to reclaimers as to what level of treatment is necessary for a residual to be delisted as would predetermined toxicity limits.

8.7.11 Enforcement Bounties

According to a GAO report on the difficulty of detecting or deterring illegal disposal of hazardous waste (GAO 1985), one of the mechanisms through which States have been most successful in obtaining information on illegal disposal has been through informants. Not infrequently, these informants have been employees who were either generally dissatisfied with their employer or were specifically unhappy over the illegal handling of hazardous wastes. GAO recommends that a bounty program might be a fruitful expenditure of enforcement dollars.

Observations:

- While there is precedent at the Federal level for a bounty program under the Rivers and Harbors Act of 1899, what is being recommended here is simply that EPA encourage States and localities to undertake such an approach, and keep a public record on the results.
- This would be an extremely low-cost effort for EPA, and might encourage activity that would lead to identification of noncompliance by smaller generators who, in some cases, may not even have been identified as hazardous waste generators by the State.

9. ANALYSIS OF FINDINGS

This report has identified trends and patterns in the practice of waste minimization by U.S. industries. It has explored the relationships between the causes of hazardous waste generation and the volumes generated, as well as the extent to which source reduction and recycling are practiced. Waste minimization practices have been characterized both by major industrial processes (source reduction) and by major waste stream categories (recycling).

Economics, regulatory requirements, liability issues, technology limitations, and attitude/organizational issues all contribute to a generator's decisions regarding waste minimization practices. This study has identified aspects of these factors that promote or inhibit the adoption of waste minimization practices.

Some of the conflicts that affect the decision to employ waste minimization practices may be resolved through the efforts of various State and Federal regulatory and nonregulatory programs. The nature of these conflicts, along with the potential of the programs to resolve them, was used to develop options to promote waste minimization. These options have been described and analyzed with respect to the possible effects of their implementation. EPA will develop and refine the stated options in preparation for the mandated Report to Congress on waste minimization.

9.1 Trends in Waste Minimization

Until recently, waste minimization was undertaken primarily for purposes other than for reducing wastes. Waste minimization was an incidental result of efforts to decrease manufacturing costs through improvement of yields and operating efficiency. With the requirements of RCRA and the recent passage of HSWA, however, companies have begun to consider such practices as a means to reduce wastes, liabilities, and the costs associated with regulation.

Neither source reduction nor recycling is a major component of industrial waste management practice in the United States. The total volume of hazardous waste recycled in 1981 was 4 percent of the volume generated, based on the population surveyed (RIA Mail Survey for Generators). Although the overall rate of recycling is low, the survey data indicate certain waste stream-specific patterns. For example, suitability of a waste for recycling depends on market demand for and the purity of the material. Another observation is that the higher the weighted average concentration of known constituents in a waste stream, the more likely is the selection of recycling as a waste management option.

The ratio of waste recycled to waste generated for the ten highest volume generators suggests that the waste streams most likely to be recycled are those with high-volume, heavy-industry applications. This pattern is suggested by the economies of scale. Generally, it is more cost-effective to recycle large volumes of materials than small volumes because of the payback period involved.

Although economics favors recycling of any large volume of waste generated, the profile drawn from the RIA Mail Survey data implies that characteristics of the waste stream are more important than volume generated in determining the technical and economic feasibility of recycling. Automobile manufacturers (SIC 37) recycled 39 percent of 900 M gal of waste generated in 1981, compared to the 1.2 percent of 28,000 M gal of generated waste recycled by chemical manufacturers (SIC 28). The limiting factor for recycling within these industries is not the volume of waste generated, but the type of process and nature of the wastes generated.

The uniformity and constituent concentrations of a waste stream are important in determining the technical feasibility of reclaiming the waste at a reasonable cost. Segregated wastes (e.g., wastes from a continuous process) are more likely to be recycled than wastes that are mixed. This is evidenced by the fact that, in 1981, dilute inorganic and cyanide/reactive waste streams from continuous processes were recycled in the highest volumes of all hazardous wastes. Pickling liquor, metal finishing solutions, and spent acids and alkalies were the wastes reported to be recycled in the largest volumes (RIA Mail Survey for Generators). In contrast, mixed solvent wastes from equipment cleaning and degreasing operations (e.g., from the trucking and warehousing industries, SIC 42) are not easily separated into their constituents; therefore, although solvent wastes were generated in high volumes, recycling rates for solvent wastes were lower in 1981 than for some inorganic waste streams.

Recycling by high-volume generators tends to be performed onsite as the volume of waste increases, whereas most small quantity generators (SQGs) ship wastes offsite for recycling. Economies of scale may contribute to this pattern, as well as the lack of expertise and equipment among many SQGs to perform onsite treatment operations.

The trend toward future reduction of waste generation appears to be significant. Estimates range from 15 to 30 percent reduction of unit waste per unit product based on the current level of waste generation. These reductions would result from the extension of existing source control techniques and the application, to their fullest potential, of new technologies identified in Appendix B.

Although Good Operating Practice (GOP) is generally well accepted, understood, and the most frequently applied source control technique, there is substantial potential for improvement. A common business practice is to select source control procedures that are obvious, easy, and relatively inexpensive to implement. Nevertheless, management initiatives to promote waste minimization activities are still needed as incentives to companies to adopt them.

Of all source reduction techniques, product substitution is the most controversial. Product substitution involves an evaluation of the substitute's feasibility with respect to (1) its adequacy as a replacement for the original product, (2) its environmental benefit compared with the original product, and (3) its compatibility with a free market economy. With respect to item 3, industry generally views the inclusion of product substitution as an inappropriate waste minimization technique. It is held that such categorization hints of governmental intrusion into the free marketplace.

9.2 Nontechnical Factors That Promote and Inhibit Waste Minimization

Economic Issues

Investment in innovative waste minimization technologies is influenced by the profit and risk associated with the innovation, as well as cost; capital availability; the adaptability of the technology; market and regulatory factors; and internal production factors. If a firm lacks the ability to raise funds for a project, the firm will not undertake it. Companies that are able to obtain sufficient capital at an acceptable cost are in a better position to implement new waste minimization technology. A firm may be motivated to raise funds, however, if the investment may result in a potential for increased profit and if the payback period is reasonably short. Market factors play a significant role in investment in recycling technologies. If there is a limited market for the material reclaimed from a waste, then there may be little or no return on the initial investment for the reclamation technology.

Product quality is a critical consideration for all waste minimization investments, however. If the innovation will cause lower production costs or improve product quality, the firm has an incentive to invest. On the other hand, if product quality is sacrificed as a result of the waste minimization effort, the firm is highly unlikely to make such an investment, since the product may no longer be as desirable. For example, manufacturers of electronic equipment (e.g., printed circuit boards) require a high degree of purity in their solvents. Many choose to use virgin solvent rather than recycled material. Although the costs for recycled materials (particularly when recycled onsite) may sometimes be less than for virgin materials, the risk of inferior product quality represents a potential loss in profits. The company would thus consider risk of losses to outweigh the cost savings resulting from use of recycled materials.

A major incentive to invest in waste minimization technologies is the increasing cost and/or banning of land disposal of hazardous wastes. HSWA impose restrictions on the land disposal of certain hazardous wastes. In the case of liquid hazardous wastes, there is an absolute ban on landfilling. In addition, the increased technological requirements imposed on new landfills may cause costs of land disposal to increase substantially. Finally, there may be a decrease in the number of permitted landfills because of the inability of the owners to comply with the requirements. The restrictions thus force generators to consider alternative forms of waste management, among them source reduction and recycling. The decrease in demand for landfills, coupled with a decrease in their supply, would result in increasing costs. Thus, technologies and methods that were once marginally economical may now be economically attractive.

Liability Issues

The risk of future liability resulting from damages caused by subsequent handling of hazardous waste may inhibit shipping wastes offsite for recycling. Conversely, it may promote onsite recycling as well as source reduction practices. Some companies may lack the in-house expertise for such activity, however, and may also feel that it is a departure from their normal production activity. Under Section 107(a) of the CERCLA statute, generators potentially can be subject to pay for damages caused by the future handling of their hazardous waste; thus, generators could be made to pay for damages caused by recyclers. Where recycling companies are inadequately insured, therefore, the potential future risk to companies sending their wastes to recyclers increases.

Some companies that send their wastes offsite are aware of this problem and attempt to prequalify the offsite waste management or recycling firm. This involves an audit of the recycler. In addition, companies may find that source reduction is a viable alternative in light of future liability costs. Although the incentive exists for companies that can afford to make such investments, this may not be possible for smaller companies. Many simply cannot afford to conduct audits of their recyclers, yet they lack the resources and in-house expertise to enlist onsite recycling or source reduction.

The cost of some recycled materials may be higher than that of virgin materials because of the high transportation costs associated with liability. Under the CERCLA legislation, transporters (as well as generators) may be held liable for future damages associated with hazardous wastes. This liability provision for transporters applies to hazardous wastes, but not hazardous virgin materials. Thus, transporters may charge more for shipping hazardous wastes in order to ensure that they are capable of paying for future environmental damages for which they may be held liable. (The definition of solid waste, as revised, would not subject to regulation wastes that are directly used or reused, provided they are not reclaimed prior to or during their use. Materials so exempted from regulation would not need to be manifested and would enjoy the same regulatory treatment as virgin materials.) Since virgin materials may be cheaper than hazardous wastes needing reclamation, this would inhibit such practices, notwithstanding issues of product quality.

Regulatory Issues

HSWA will increase awareness of waste minimization as an alternative, and may also result in such practices being viewed as economically attractive relative to other waste management techniques. As mentioned previously, the provisions for land disposal restrictions and increased requirements for landfills found in HSWA are likely to cause generators to give more serious consideration to other waste management alternatives, among them source reduction and recycling. Because of these recent legislative and regulatory developments, some companies, who might never have done so, may now consider waste minimization. Other companies, for whom waste minimization was actually a result of changes designed to increase product yield, may now give primary consideration to these practices in light of land disposal restrictions and limited waste management alternatives.

RCRA and other regulations may serve to inhibit waste minimization activities that require permits. Waste minimization activities that require the installation of new equipment onsite may be considered to be treatment facilities under the RCRA regulations. Although at present reclamation activities are not subject to regulation, other activities that do not qualify as reclamation may require permitting. Since permitting can be a slow, unpredictable, and costly process, it may serve to inhibit waste minimization activities for which permits are required. Similarly, permits are required for hazardous wastes stored onsite for more than

90 days. In order for recycling to prove economical, sufficient volumes must be recycled. Smaller companies may not generate enough wastes in a 90-day period to warrant shipping them offsite, yet to accumulate the waste onsite would require permitting; such smaller companies may find other means of waste management more economical. With restrictions on land disposal in the future, this situation has the potential to lead to increases in illegal disposal.

In addition to RCRA permits, permits for air and wastewater emissions also may be required before new equipment is installed. Air permits may be difficult to obtain in areas of the country in which one or more of the national ambient air quality standards are violated, since offsetting emission reductions would be required to satisfy the permitting requirements.

Increased requirements and misinterpretations of EPA's revised definition of solid waste may inhibit both onsite and offsite recycling. EPA's new definition of solid waste requires that some wastes that previously did not need to be manifested when shipped offsite for recycling now must be manifested if reclamation is involved. Because of the fear of future liability for damages under CERCLA, manifesting wastes is seen to inhibit such offsite recycling. The definition also contains confusing language, which has been misinterpreted by both industry and some State agencies. Although reclamation activities currently are not regulated, some people feel that the installation of equipment to perform onsite recycling will require a permit. The difficulty of misinterpretation is compounded when State agencies believe this to be correct and incorporate such an interpretation in their version of the regulations.

The problems associated with siting waste treatment facilities are obstacles to expanding resource recovery capacity. An increase in offsite recycling may create a need for additional facilities; however, recyclers face difficulties in finding new sites and obtaining timely approval of permits. Siting of such facilities often results in the "not in my backyard" reaction. Such reactions are due to past practices and increased publicity (and fear) of hazardous waste problems. They also may be due to the failure of State or local governments to educate communities on the costs and benefits of such sites and their relation to the local job base. In some cases, prospective operators are unwilling to enter into dialogues with the community about the prospective facility and its design and operations.

Attitude/Organizational Issues

The effect of current practice on industrial design may serve to inhibit development of waste minimization practices within companies. There is a tendency to preserve designs and practices that may generate large volumes of waste because they have worked well and provide ready solutions to production problems. Familiarity with production techniques also results in lower time and personnel requirements. As a result, company managements may be satisfied with status quo production operations, in spite of their tendencies to produce large volumes of waste.

Opposition to possible waste minimization measures may arise out of fear of reduced product quality. This is only one factor, however. Process modifications may also involve production downtime that impedes fulfillment of production goals or contractual obligations. Thus, process modifications are viewed as a relatively expensive endeavor.

Corporate policies can influence waste minimization practices. To increase awareness and motivation, companies may provide waste minimization newsletters, cash awards, certificates, seminars, and workshops. Without effective communication, engineers responsible for production operations may not be fully cognizant of the problems associated with hazardous waste handling and disposal and the potential environmental liabilities associated with generated waste streams. Effective communication of the corporate waste minimization policy to all operational levels contributes to the implementation of a successful waste minimization program. Upper management support, however, is especially necessary. In particular, the program requires a "champion," a person at an upper level who is committed to waste minimization. Such a person can overcome both developmental problems and the general inertia that protects existing waste-producing practices.

9.3 Governmental Efforts to Promote Waste Minimization

State Programs

Some State agencies provide information to increase awareness and to educate the regulated community on waste minimization. Many States have information programs, which disseminate waste minimization information through publications and conferences. Technical Assistance Programs are another form of information program, providing generators with specific technical advice on how their processes could be altered to reduce waste generation. Such programs are particularly helpful to smaller companies that lack the resources or in-house expertise to make such evaluations. The programs include advice on regulatory matters, which could also aid smaller companies unfamiliar with Federal and State requirements. Such programs may effectively complement corporate efforts in waste minimization.

Financial incentives in the form of loans, grants, and fee and tax systems also promote waste minimization. Some States have instituted loan and grant programs for projects involving installation of equipment associated with source reduction or recycling. Other programs are structured in the form of awards, which are sums of money awarded to firms in recognition of their efforts to reduce pollution. Such grant, loan, and award programs promote waste minimization by "seeding" the investment process within a firm, and in so doing, share some of the risk.

Taxes and fees are also forms of financial incentive. The fee and tax systems of various States are structured to serve as incentives to minimize waste. In some States they are assessed on the basis of amounts of wastes disposed. This tax, called a "waste-end" tax, is levied primarily to generate revenue and to make land disposal the least preferred alternative, thus attempting to encourage waste reduction. These two goals -- revenue generation and waste reduction -- potentially conflict with one another, however, because States may lose a significant source of revenue if land disposal is severely discouraged.

Federal Programs

Federal waste minimization programs include research and development and technology transfer. Research and development on waste minimization are being conducted by various Federal agencies including EPA, the Department of Energy, and the Bureau of Mines. The Tennessee Valley Authority receives $1.5 million in Federal appropriations per year to implement its waste management program. Research is also being conducted by Congressional agencies such as the Office of Technology Assessment and the Congressional Budget Office. OTA is conducting a study on source reduction, which will examine State and Federal activities and provide policy options on the types of programs that the Federal Government can implement to enhance source reduction. CBO has completed a study examining the different types of waste-end tax systems as ways of encouraging waste reduction.

The Department of Defense waste minimization program may serve as a model for some industries, and thus is a significant information source on waste minimization and its implementation. As a generator of hazardous waste, DOD is involved in waste minimization at both the research and implementation levels. Since 1980, DOD has made it a policy to limit the generation of hazardous waste through alternative procurement policies and operational procedures. Waste minimization activities are implemented through the Defense Environmental Leadership Project, the Defense Logistics Agency, and the efforts of the individual bases or installations themselves. Recently, the Joint Logistics Chiefs (JLC) of the services developed a waste minimization strategy and proposed it for adoption on a DOD-wide basis. The program would include a review of procedures and equipment for application, increased research and development, and an inter-service information exchange/technology transfer.

Some of the activities underway at various bases include the use of bead blasting for paint removal and the use of water-borne paints rather than those that are solvent based. The Air Force System Command (AFSC) recently completed a study of the Air Force's contract suppliers to evaluate the extent to which waste minimization is practiced in their operations. Because of the large market influence exerted by the military, projects that affect the production practices of the military's suppliers, as well as those within military bases themselves, may have far-reaching effects on nonmilitary industries.

9.4 Options to Further Promote Waste Minimization

Options to further promote waste minimization were developed as possible means to meet the national policy objective of waste minimization added to Section 1003 of RCRA by HSWA. The factors that promote and inhibit waste minimization, as well as government regulatory and nonregulatory programs to encourage waste minimization, were instrumental in developing options for the promotion of waste minimization. In some cases, the options identified were based on programs that are actually in place; in other cases, they were based on those that are proposed. Performance standards, management practices, and a broad array of economic incentives represent the types of options developed. Options took the form of regulatory programs under RCRA and other environmental laws, nonregulatory programs, and legislative changes.

The options were designed in part to alleviate some of the problems and conflicts identified in current regulatory programs. In particular, one option examines changes that could be made to EPA's definition of solid waste to potentially alleviate some of the disincentives to recycling. Another option reviews the various forms of waste-end taxes and suggests that the money from such taxes be used to fund grant programs dedicated to companies who invest in new equipment that reduces waste. Also considered was the option of "no change," in which HSWA remain as written. As discussed above, HSWA requirements will force many companies to consider, perhaps for the first time, waste management alternatives to land disposal.

The degree to which HSWA by themselves effect an increase in waste minimization will be significant in determining whether additional performance standards or management practices are desirable. Such information probably will not be evident for several years. Other options suggested may be effective in encouraging waste minimization independent of the effect of HSWA. Such options may provide an immediate opportunity for innovative Federal and State approaches to the problem.

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Report to Congress

Minimization of Hazardous Waste

Executive Summary
and
Fact Sheet

October 1986

Printed on 75% Recycled Paper

Report to Congress

MINIMIZATION OF HAZARDOUS WASTE

Summary of Recommendations

The Environmental Protection Agency has concluded that mandatory standards of performance and required management practices are not feasible or desirable at this time. The Agency recommends that the effect on waste minimization of the land disposal restrictions and other HSWA mandates, as well as amendments to CERCLA, be quantified and analyzed. EPA will report back to Congress on this determination in December 1990, the earliest date at which it believes a recommendation on the need for a major waste minimization regulatory program could be made. Until that time, however, EPA recommends a three point waste minimization strategy:

Information Gathering

Continuing collection of information on waste stream volume and composition, generation rates by various types and sizes of generators, adequacy of capacity for TSD facilities, and the cumulative effect of HSWA requirements on voluntary waste minimization practices.

Core Waste Minimization Program

- Development and publication of informal guidance on waste minimization for the purpose of the reporting and certification requirements of HSWA Sections 3002 and 3005.
- Provision of a technical and information assistance program to generators and to States to aid in the development of waste minimization programs.
- Assistance to specific States to develop programs for providing direct technical assistance to generators (e.g., using waste audits, dissemination of technical information, applied research on new applications of existing technology).
- Highlight ongoing research and development and economic feasibility studies that might serve an entire region or have regional application.
- Development of an information system on waste minimization, accessible by the States.
- Implementation of mandatory controls, as needed, for controlling the generation of wastes for specific industries or processes using current authority under TSCA Section 6.
- Incorporation of waste minimization into the review of TSCA Premanufacture Notices.

Longer Term Options

After evaluation of information gathered in the short term, EPA may better assess in its 1990 report to Congress that additional authority to adopt mandatory standards of performance or management practices as a means of reducing wastes would be warranted.

In the interim, EPA will continue to examine the specific elements of the "core" waste minimization program and consider the need for longer term options, if needed. As part of the next RCRA reauthorization, EPA will provide Congress with its most current assessment of the need to modify the existing waste minimization requirements for generators and TSDFs. Among the possible options to consider would be:

- To prohibit, where appropriate, certification of certain types of waste management practices as waste minimization.
- To specify what may be certified as waste minimization.
- To define necessary documentation for certifications that state that waste minimization is not economically practicable.

Report to Congress on Minimization of Hazardous Waste

EXECUTIVE SUMMARY

This Report to Congress is submitted in response to the requirements of Section 8002(r) of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act (RCRA) of 1976, and the Hazardous and Solid Waste Amendments (HSWA) of 1984.[1] Under this section, the Administrator of the Environmental Protection Agency (EPA) is required to submit a Report to Congress by October 1, 1986, recommending any legislative changes that are feasible and desirable to implement HSWA's policy with respect to the minimization of hazardous waste:

> The Congress hereby declares it to be the national policy of the United States that, wherever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible. Waste that is nevertheless generated should be treated, stored or disposed of so as to minimize the present and future threat to human health and the environment.

Section 8002(r) requires the Administrator to evaluate specifically the feasibility and desirability of:

1. Establishing standards of performance or of taking other additional actions under RCRA to require generators of hazardous waste to reduce the volume or quantity and toxicity of the hazardous waste they generate; and

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[1] Reflecting common usage, the amended Solid Waste Disposal Act will hereafter be generally referred to as RCRA. Additions to RCRA made by the 1984 amendments will be referred to in the text as HSWA.

2. Establishing, with respect to hazardous waste, required management practices or other requirements to ensure such wastes are managed in ways that minimize present and future risks to human health and the environment.

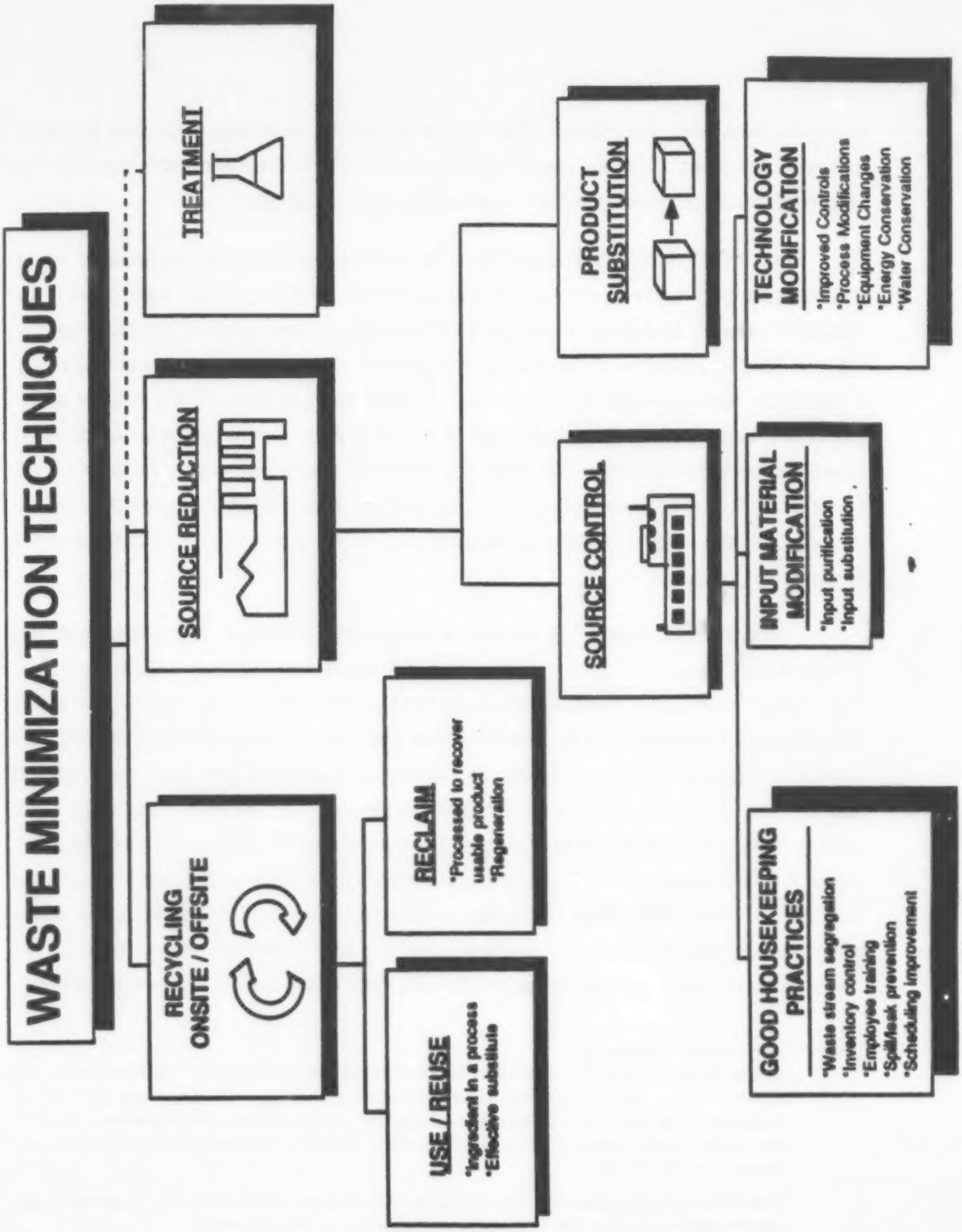
Definition of Terms

The following definitions, based in part on the interpretations presented below, are crucial to the recommendations made in this report (see also Figure 1):

> **Source reduction** refers to the reduction or elimination of waste generation at the source, usually within a process. Source reduction measures can include some types of treatment processes, but they also include process modifications, feedstock substitutions or improvements in feedstock purity, various housekeeping and management practices, increases in the efficiency of machinery, and even recycling within a process. Source reduction implies any action that reduces the amount of waste exiting from a process.
>
> **Recycling** refers to the use or reuse of a waste as an effective substitute for a commercial product, or as an ingredient or feedstock in an industrial process. It also refers to the reclamation of useful constituent fractions within a waste material or removal of contaminants from a waste to allow it to be reused. As used in this report, recycling implies use, reuse, or reclamation of a waste either onsite or offsite after it is generated by a particular process.
>
> **Waste minimization** means the reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored, or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of hazardous waste, or (2) the reduction of toxicity of hazardous waste, or both, so long as the reduction is consistent with the goal of minimizing present and future threats to human health and the environment.

In the broadest sense, the HSWA defines waste minimization as any action taken to reduce the volume or toxicity of wastes. That definition includes the concept of waste treatment, which encompasses such technologies as incineration, chemical detoxification,

FIGURE 1


WASTE MINIMIZATION TECHNIQUES
RECYCLING ONSITE / OFFSITE
SOURCE REDUCTION
TREATMENT
USE / REUSE
*Ingredient in a process
*Effective substitute
RECLAIM
*Processed to recover usable product
*Regeneration
SOURCE CONTROL
PRODUCT SUBSTITUTION
GOOD HOUSEKEEPING PRACTICES
*Waste stream segregation
*Inventory control
*Employee training
*Spill/leak prevention
*Scheduling improvement
INPUT MATERIAL MODIFICATION
*Input purification
*Input substitution
TECHNOLOGY MODIFICATION
*Improved Controls
*Process Modifications
*Equipment Changes
*Energy Conservation
*Water Conservation

biological treatments, and others.[2] The Agency has already embarked on a broad program for waste treatment; thus, this report focuses on source reduction and recycling, the two aspects of waste minimization where basic options still remain open.

Section 1003 of HSWA establishes the general national policy in favor of waste minimization and refers to the need to reduce the "volume or quantity and toxicity" of hazardous wastes. EPA does not interpret this language to indicate that Congress rejected volume reduction alone (with no change in the toxicity of hazardous constituents) as being a legitimate form of waste minimization. A generator that reduces the volume of its hazardous waste, even if the composition of its waste does not change, is accomplishing beneficial waste minimization. EPA believes that waste concentration may occasionally be a useful waste minimization technique (e.g., in preparing materials for recycling). The key concept, however, is that waste minimization must be protective of human health and the environment.

Because both volume and toxicity of wastes present dangers to human health and the environment, measuring the effectiveness of waste minimization will be complex. First, waste minimization measures are likely to be process and industry specific, implying that different measurement techniques might be needed in different contexts; second, any mandatory requirements for reducing the volume or toxicity of generated waste should directly relate to expected reductions in risk to human health and the environment. EPA has already developed data and methodologies that can be used to evaluate the risks of many types of waste streams, as well as the risk reductions associated with waste management practices.[3] These evaluation techniques will continue to improve and become more effective as a tool in regulatory decision making. EPA therefore intends to use such assessments as a means of measuring progress in waste minimization and to help establish priorities among or within possible waste minimization regulatory schemes. This approach is consistent with the general principle that any waste minimization regulations should seek to reduce significant remaining risks.

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[2] Section 1003(a)(6) of HSWA states that the objectives of "promot[ing] the protection of health and the environment and conserv[ing] valuable material and energy resources" can be done by "minimizing the generation of hazardous waste and the land disposal of hazardous waste by encouraging process substitutions, materials recovery, properly conducted recycling and reuse, and *treatment*" [italics added].

[3] These include, for example, the Liner Location Model and the RCRA Risk/Cost Analysis Model (usually referred to as the Waste-Environment-Technology or W-E-T model).

Why Minimize Waste?

The RCRA program over the past ten years has focused primarily on correcting the effects of years of poor management of hazardous wastes by bringing treatment, storage, and disposal facilities into compliance with national standards that are protective of human health and the environment. HSWA has continued this policy, but has also shifted the emphasis of the program away from reforming land disposal practices to a reliance on waste treatment. Because of its potential for contamination of other environmental media (e.g., ground water), land disposal—even under strict control—is recognized as the least desirable method of managing hazardous wastes.

The move toward treatment is a major step forward, but is not a complete answer. Reforms in land disposal practices and installation of new hazardous waste treatment capacity are effective responses to managing this country's hazardous waste, but they do not address the generation of these wastes. Both Congress and EPA believe that preventing the generation of a waste, when feasible, is inherently preferable to controlling it after it is generated. Waste minimization can be viewed as a means of reducing the introduction of hazardous constituents into all environmental media.

Current environmental control programs are designed to protect human health and the environment. However, control technologies are never 100 percent efficient, and compliance with regulations under any environmental program can never be perfect, even with the most stringent enforcement program. Waste minimization can also address the risks of breakdowns in waste management systems.

In addition to achieving human health and environmental benefits by reducing the volume and/or toxicity of hazardous wastes, waste minimization can also relieve shortages of treatment, storage, and disposal capacity. The capacity to accept wastes diverted from land disposal will be especially limited over the next few years while new facilities are under construction and treatment alternatives are being developed. This process may be slow, since public opposition makes new hazardous waste facilities extremely difficult to site. Furthermore, land disposal will continue to be required into the foreseeable future, even if wastes disposed of in or on the land are detoxified first; hence, capacity needs will always be a concern. Finally, all forms of waste management—treatment or land disposal—must allow for industrial growth and thus the need for additional capacity. By reducing per unit product generation rates, waste minimization can provide at least a partial answer to these problems.

Incentives and Disincentives for Waste Minimization

Strong incentives already exist to promote waste minimization in the private sector, including (1) dramatic increases in the price of all forms of hazardous waste management, partially caused by Federal and State standards, (2) difficulties in siting hazardous waste management capacity, (3) permitting burdens and corrective action requirements, (4) financial liability of hazardous waste generators, (5) sharp increases in the cost of commercial liability insurance, coupled with a steep dropoff in its availability, and (6) public pressure on industry to reduce the production of waste. There are also countervailing disincentives. Figure 2 covers the incentives and disincentives that surround the various waste minimization techniques.

Incentives for Waste Minimization

Increases in the costs of hazardous waste management: EPA and State regulations have been the primary cause of increased costs in treatment, storage, and disposal of hazardous wastes, especially in relation to landfills, surface impoundments, and storage and accumulation tanks. The current series of land disposal restrictions under HSWA will limit the number of untreated wastes that can be disposed of on land and thus are likely to increase the cost of disposal. HSWA also imposes more stringent standards on surface impoundments, which will mean that about half of those now in operation will close. In addition, the recently promulgated hazardous waste tank rules[4] will

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[4] 51 FR 25421, July 14, 1986

	Source Reduction	Offsite Recycling	Onsite Recycling
INCENTIVES			
Increased Cost of Waste Management	●	●	●
Difficulties in siting new HW management facilities	●		●
Permitting Burdens and Corrective Action Requirements	●	●	●
Financial Liability of HW Generators	●		●
Shortages of Liability Insurance	●		●
Public Perception	●	●	●
DISINCENTIVES			
Economic Barriers –Lack of Capital	●		●
–Financial Liability		●	
Technical Barriers –Attitudes toward unfamilar methods	●	●	●
–Batch Processes			●
–Lack of information	●	●	●
–Technical Limits of Process	●		
–Technical Quality Concerns	●		
Regulatory Barriers –Need to Obtain TSD Permit	●	●	●
–Perceived Stigma of Man'g Haz. Waste		●	●
–Revisions to Other Env. Permits	●	●	●

FIGURE 2 INCENTIVES AND DISINCENTIVES FOR VARIOUS WASTE MINIMIZATION TECHNIQUES

also increase waste management costs. Because of these three factors, generators must find alternative means for treating, storing, or disposing of their wastes.

Prices for such alternative waste treatment are expected to rise as generators compete for scarce treatment capacity (such as incineration or chemical detoxification). EPA has, in fact, already identified shortages of treatment and disposal capacity for solvent and dioxin wastes in its proposed regulations.[5]

Overall, the increased costs of waste management provide a strong incentive for owners and operators to reduce the quantity of waste generated or disposed of through the use of source reduction and offsite and onsite recycling techniques.

Difficulties in siting hazardous waste treatment, storage, and disposal capacity: The land disposal restrictions program, as mandated by HSWA, is creating a strong demand for substantial new waste treatment, storage, and disposal capacity. Hazardous waste managers are therefore seeking new sites and planning to expand existing ones, but in the process they are encountering the familiar problem of "not in my community." While there are some instances where States have been successful in helping to site new hazardous waste management facilities, local resistance tends to be extremely hard to overcome. This intense public opposition to the siting of many types of hazardous waste facilities may cause shortages to persist even when market demand is strong. Generators' only alternative in many cases may therefore be a reliance on source reduction and onsite recycling to reduce the amount of waste they would otherwise send to offsite management facilities.

Permitting burdens and corrective action requirements: Even though the demand for new treatment and disposal capacity will be high, permitting procedures will tend to delay the availability of that new capacity, temporarily driving up the costs of all forms of treatment and disposal. No new hazardous waste management facility may be constructed until it has acquired a RCRA permit—a costly process that usually takes several years to complete. In addition, all permits issued after November 8, 1984, include provisions requiring owners and operators to take corrective action for releases of hazardous waste, regardless of when it was placed in the unit, both within *and beyond* property boundaries as necessary to protect human health and the environment. This potentially very expensive requirement applies to all facilities seeking a new RCRA permit, including both existing and new facilities. Additionally, even though the demand for new treatment and disposal capacity will be high, permitting procedures will tend to delay the availability of that new capacity, temporarily driving up the costs of all forms of treatment and disposal.

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[5] 51 FR 1729, January 14, 1986

Thus, the increased costs of permitting burdens and corrective action provide still another strong incentive for owners and operators to reduce the quantity of waste generated or disposed of through the use of source reduction and offsite and onsite recycling techniques.

Financial liability of hazardous waste generators: Generators using offsite treatment, storage, or disposal face financial liability for two reasons: (1) there is a potential for mismanagement of wastes by facility operators, and (2) there is the possibility of improper design of the disposal facility itself. Even careful evaluation of facility management cannot reduce these risks to zero. A generator risks incurring liability when the treatment, storage, or disposal facility (TSDF) owner or operator cannot or will not pay for remedial or corrective actions made necessary by migration of wastes. In these situations, generators can be held liable under common law for absolute, strict, joint and several liability. In addition, the imminent and substantial endangerment provisions in Sections 106 and 107 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), state a generator or generators can be held financially responsible for the entire cleanup or restoration of a facility. When less waste is generated, it reduces potential liability for future disposal and thus is an incentive for both source reduction and onsite recycling.

Shortages of liability insurance: The traditional means for obtaining coverage for potential hazardous waste management liabilities is through insurance, but, for many generators and owners or operators of TSDFs, liability insurance is no longer available, or is available only at extremely high cost. This is particularly true of Environmental Impairment Liability (EIL) insurance, which until 1985 was an often-used financial instrument for generators and owners and operators of TSDFs to protect themselves from third-party and government claims for damages resulting from environmental releases of hazardous substances. In recent years, premiums have increased 50 to 300 percent, policies have been cancelled even where loss ratios have been excellent, and many companies have difficulty obtaining coverage at any price. In order to insure themselves against liability, TSDFs who must comply with Sections 3004 and 3005 (e) of RCRA[6] have resorted to creative methods to obtain coverage.[7] Until fundamental changes occur in the insurance marketplace, many generators and TSDFs will continue to have difficulty meeting liability requirements.

Increases in insurance costs or an inability to obtain insurance will result in higher treatment and disposal costs or the loss of available treatment or disposal capacity. This will provide a strong incentive to reduce the quantity of waste to be disposed of through the application of source reduction and onsite recycling techniques.

Public perception of company responsibilities: While the strongest incentives for implementing waste minimization techniques are probably economic, many companies are establishing waste minimization programs out of sensitivity to public concern over toxic chemicals. This type of corporate good citizenship is felt to produce good relations between industry and the public. Available information indicates that the larger companies are most likely to perceive public relations benefits in waste minimization; however, some medium and small size companies are acting under the same motives.

Disincentives for Waste Minimization

Economic barriers: Even though waste minimization practices often lead to cost savings, availability of capital for plant modernization is often a significant obstacle to their implementation. Although major companies may have sufficient access to upgrade inefficient processes, small and medium sized companies often do not. Firms that have recently modernized their facilities have reduced incentive to reinvest in alternative processes. Obstacles to plant modernization adversely affect the implementation of source reduction and onsite recycling when these involve process modifications.

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[6] Generators do not have to obtain liability insurance under RCRA.

[7] New instruments they have developed include: (1) formation of associations—captive stock or mutual insurance companies, (2) licensed carrier fronting programs for trust funds in which banks hold funds to cover liability, (3) letters of credit, (4) self insurance, and (5) corporate guarantees.

Financial liability can, in at least one circumstance, also be a significant disincentive for waste minimization because generators who send waste offsite may be liable under CERCLA and common law for damages caused by their wastes, even if the wastes have left the plant and are no longer under the firm's control. They may therefore not use available offsite recycling.

Technical barriers: Some firms may be reluctant to make any modifications to their production processes for fear of risking the technical quality of their final product. While these fears may not be well-founded, they can be a significant impediment to innovation.

There may also be, however, significant practical limits to waste minimization, especially with respect to source reduction, even where firms are actively seeking to minimize waste. Certain products simply cannot be manufactured without producing hazardous wastes; excessive waste minimization requirements would, in such cases, remove products from the market or put companies out of business entirely. A hazardous waste analog to the zero discharge policy, calling for across-the-board cuts of fixed percentages of waste generated, is therefore not realistic because, in some situations, possible source reductions may turn out to be minor and achievable only at great expense.

Another technical consideration affecting waste minimization is that industries producing high volume or high toxicity wastes often operate largely through batch processes. This can present problems for certain onsite recycling techniques (e.g., while light colored off-specification batches of paint can be blended into subsequent darker colored batches, the opposite is not always true).

Similarly, offsite recycling is often technically limited by process realities and administrative logistics. Off-specification chemicals (such as pesticides or pharmaceuticals) are examples of products with little onsite or offsite recycling potential. Even where wastes are technically recyclable, it may be difficult to accumulate enough waste to make the activity economically attractive. With respect to offsite recycling, it may be hard to establish permanent and stable relationships, either onsite among various production lines or offsite among firms; generator and user processes have to be synchronized, purity may vary over time, volumes of wastes available may not meet minimum reuse needs, transportation costs have to be acceptable, and price variations in feedstocks and in product prices inevitably play a crucial role.

Finally, the most significant technical barrier to waste minimization may often be a lack of suitable engineering information on source reduction and recycling techniques. Available information suggests that this is most often the case with small and medium sized companies.

Regulatory barriers: Some of the provisions of current environmental statutes, including RCRA, tend to discourage waste minimization. Some examples include the following:

- Source reduction sometimes requires the installation of new machinery that can, under RCRA, be considered "treatment." This in turn may require a plant to obtain a permit as a treatment, storage, and disposal facility (TSDF).
- Commercial recycling facilities that wish to increase their operations might be reluctant to do so if the expansion were to require a revision of their NPDES water pollution permit to authorize a change in the composition of their discharges or allow for larger flows.
- The new definition of solid waste, promulgated by EPA to eliminate loopholes in RCRA controls and inhibit unsafe (or "sham") recycling, brings some additional wastes into the hazardous waste system. This seems to be inhibiting some plants from sending these wastes offsite for recycling, since many companies perceive that manifested wastes present greater financial liability for offsite activities out of their immediate control. In addition, out of anxiety over potential financial liabilities, some companies not currently in the hazardous waste system may be reluctant to undertake any waste minimization program that would require them to accept manifested hazardous waste (e.g., certain offsite recycling practices) or take other measures that would bring them officially into the hazardous waste management system.

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Current Waste Minimization Requirements

At present, there are three formal statutory requirements relating to waste minimization, all of them enacted as part of the 1984 amendments.

1. Section 3002(b) of HSWA requires generators to certify on their waste manifests (mandated under Section 3002(a)) that they have in place a program "to reduce the volume or quantity and toxicity of such waste to the degree determined by the generator to be economically practicable."

2. Section 3005(h) of HSWA requires the same certification in relation to any new permit issued for treatment, storage, or disposal of hazardous waste.

3. Section 3002(a)(6) of HSWA requires, as part of any generator's biennial report to EPA, that the generator describe "the efforts undertaken during the year to reduce the volume and toxicity of waste generated" as well as "changes in volume and toxicity of waste actually achieved during the year in question in comparison with previous years, to the extent such information is available for years prior to enactment of [HSWA]."

These requirements should increase the awareness of generators and facility owners and operators of the importance of minimizing hazardous wastes, and might serve as the basis for more specific and farther reaching requirements. However, the present requirements are not restrictive; the generator determines whether any particular waste minimization approach that might apply to his or her process is economically practicable.

Although the biennial reports should provide useful insight into what generators are actually doing to reduce wastes, they are not likely to provide definitive information. The reports due this year (1986) will be the first to include waste minimization requirements, and the quality of information they contain is expected to vary widely. As yet, for example, there is no formal definition of the meaning of the term "toxicity," or any guidance on the way to measure waste volume. In addition, generators are not likely to provide information that they consider confidential.

EPA is therefore conducting a study to determine how the waste minimization statement on the biennial report can be modified to improve the quality of information being reported. The Agency plans to provide uniform guidance directly to the States and to generators on the content of these reports in time for their 1988 submission. Future information provided in the report will then allow EPA to better identify trends in waste minimization technologies applied by generating facilities.

Evaluation of Available Options for Waste Minimization

Congress specifically required the Agency to report on the desirability and feasibility of establishing mandatory standards of performance for waste minimization or of taking additional actions under RCRA to reduce the volume or quantity and toxicity of hazardous waste and of establishing required management practices to achieve minimization. It also requested any recommendations for legislative changes to implement the national policy of waste minimization. This report details EPA's evaluation of the following options to minimize hazardous wastes.

Standards of Performance

Mandatory standards of performance for minimizing wastes could take various forms, but in all their variations they are markedly different in concept from the type of performance standards typical of the air and water pollution control programs. In these other programs, performance standards are end-of-pipe standards that allow flexibility to modify processes or add control technologies. Performance standards for waste minimization would depend substantially on internal modifications of industrial processes. Such standards would mark a major departure from past practice and would require statutory amendments. At present, mandatory performance standards are not authorized under RCRA.

EPA has evaluated three variations of performance standards in this report:

1. Specific standards limiting the volume or toxicity of wastes,
2. Prohibition or restriction of specific waste streams, and
3. A phasedown permit system, wherein total waste generation levels for one or more industries or waste streams are specified and then

reduced ("phased down") over time. Under this option, trades among firms for generation rights would be encouraged.

EPA believes that all these options raise significant implementation concerns and should be adopted only after careful evaluation of emerging trends and patterns of waste generation. It is important that the option selected be the most effective method to minimize hazardous waste for a particular industry. All performance standard options would be costly and time consuming to design and would, therefore, be infeasible to implement in the next four to six years. If it becomes clear after implementation of the land disposal restrictions program that there are specific residual hazardous waste problems that are not being resolved through response to these requirements, then additional prescriptive action may be appropriate. EPA might find that the Toxic Substances Control Act (TSCA), especially Section (6)(a)(A), is a more appropriate method than RCRA regulations to resolve residual hazardous waste problems.

A comprehensive command-and-control performance standard program of the traditional type would cost on the order to $5 to $7 million per standard to design and implement, and would require staff commitments at least as high as the effluent guidelines program for water or the new source performance standards program for air. At the present time, however, there are hundreds of discrete industrial processes to examine, and it is difficult to project without further information how many may require standards. Under the most realistic circumstances, it would take at least ten years after Congressional authorization to design and fully implement such a program.

Prohibition or restriction of specific wastes would presumably be simpler in regulatory structure and more selectively applied than performance standards, but would still require extensive research into processes and waste management techniques. Furthermore, responsible use of prohibition authority often requires substantial analysis of the feasibility of less severe measures and, therefore, can also be costly to evaluate.

A phasedown permit system would be somewhat different in concept and operation from a command-and-control performance standard approach. Because it would not set specific engineering standards for each industry, the burden on EPA for developing the program would be considerably less than for a conventional standard-setting process.

11

Incentives for trading among firms would be inherent in the system, since the number of permits would be limited to less than the current level of waste generated. The eventual value and distribution of permits would be set by the marketplace, with waste reductions coming from those firms that could reduce most cost-effectively. These firms would be able to sell any unused permits on the open market as "waste reduction credits." Moreover, since EPA would phase down the amount of waste generation allowed, the permits would increase in value over time, creating a continuous incentive to reduce waste further.

Phasedown permits would cost society far less than other performance standard options for achieving a given level of waste reduction if there are sufficiently wide variations in unit control costs among generators and if trades are actually made among firms. They do, however, raise novel implementation problems. Two concerns are the initial distribution of permits and the degree of trading to be allowed. However, these issues may be resolvable, as demonstrated by EPA's recent program to phase down the lead content of gasoline. A third concern is how to determine the rate of the phasedown and the amount of hazardous waste allowed at the end of the phasedown period.

Under any of these options, EPA would consider exempting small quantity generators from the requirements or would consider subjecting them to simplified and less burdensome requirements. Because small quantity generators collectively account for only a small fraction of the wastes generated annually,[8] subjecting them to stringent and expensive regulations may not be cost-effective or provide additional protection of human health and the environment.

Management Practices

Management practices, as defined in this report, are procedures or institutional policies within a service or manufacturing operation that result in a reduction in hazardous waste generation. They are a step beyond the directives established by performance standards and include requirements restricting particular disposal practices, requirements for the handling of wastes as they are generated, and requirements for controlling the waste generation system.

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[8] Small quantity generators regulated under RCRA are those who generate between 100 and 1,000 kilograms of hazardous waste per month. According to the *National Small Quantity Hazardous Generator Survey*, conducted for the Office of Solid Waste in 1985, small quantity generators, including those who generate less than 100 kilograms per month, collectively account for less than one half of one percent of the total quantity of waste generated annually.

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Three management practices are discussed below. The first would ban the landfilling, treatment, or incineration of potentially recyclable wastes. The second would require the segregation of wastes to enhance recycling potential. The third would require mandatory waste audits.

Banning the landfilling, treatment, or incineration of potentially recyclable wastes would likely be controversial and possibly inefficient. In addition, while it would be possible to make sure that no proscribed waste is landfilled, treated, or incinerated, it would be exceedingly difficult to ensure that all such waste is properly recycled instead, thus making it difficult to enforce. Noncompliance (e.g., illegal dumping) would potentially be substantial.

A second possibility would be a requirement for segregation of waste streams and banning the mixing of waste streams that are potentially recyclable. This includes the isolation of hazardous materials from nonhazardous materials or the isolation of liquid from solid waste. The segregation of wastes does have the potential in selected instances to be economically attractive, and could, in fact, save some firms significant sums of money by reducing treatment and disposal costs, lowering expenses for the purchase of raw materials, and/or generating a reclaimed product that can be marketed or sent to a waste exchange. Waste stream segregation might, therefore, become economically attractive without additional regulation. It is conceivable that new prohibitions on land disposal and dramatically increased costs for all forms of disposal, coupled with substantial efforts to increase industry awareness of recycling possibilities, could provide adequate information and incentive for segregation without making such action a regulatory requirement.

Waste audits can be an effective means to identify opportunities for waste minimization, making audits mandatory, however, could undermine their effectiveness. While the direct costs of waste audits for industry are not extremely high (on average

$10,000 to $20,000 per audit for an uncomplicated facility)[9], requiring every waste generator to conduct an audit could have some detrimental effects. If they were seen as a Federal requirement rather than as a corporate initiative, plant personnel might tend to be less than forthcoming and the results of such audits often might be discounted and disregarded. A mandatory program might also require EPA to develop implementing regulations to address who is qualified to conduct waste audits and how audits should be conducted, and to monitor possible reporting requirements. Since it would be difficult to require compliance with the recommendations of a waste audit, such efforts do not seem justified.

It appears more desirable for EPA to promote voluntary waste audits on their own merits as a useful waste management tool, such as through a technical assistance program implemented through the States (see below). EPA and the States could develop programs that would include State certification and listing of qualified waste minimization auditors, targeted assistance programs for onsite audits, and development of model checklists and protocols for conducting audits. In the context of a voluntary audit approach, such programs should be less burdensome to develop and more flexible to implement than under a mandatory regime; thus, it is suggested as an EPA initiative.

Legislative Amendments to HSWA

EPA currently interprets the certification requirement under HSWA Section 3002 (generator standards) and Section 3005 (permit standards) as prohibiting the development of substantive requirements to generators on what constitutes appropriate waste minimization. As the Senate Report on the certification process emphasizes, the intent of the current requirement is merely to encourage generators to consider specifically the desirability and feasibility of waste minimization; it does not require specific waste minimization action.

The Agency believes that generators should continue to determine what their waste minimization options are and, at this time, that EPA should not make process related decisions to force waste minimization. However, EPA is further considering an option to amend the current legislation to allow EPA to define acceptable waste minimization practices. This authority could allow EPA to specify general practices that could or could not be certified as waste minimization (e.g., those practices that result in adverse cross-media pollution transfers). EPA is continuing to evaluate this change to the waste minimization certification statement, and will provide Congress a further assessment of the need to modify these requirements. Among possible options to consider include:

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[9] For smaller facilities, the costs could be substantially lower, perhaps under $5,000; however, for large, complex facilities, the costs could be substantially higher.

- Prohibit, where appropriate, certification of certain types of waste management practices as waste minimization.
- Specify what may be certified as waste minimization.
- Define necessary documentation for certifications that state that waste minimization is not economically practicable.

As additional information becomes available, the Agency could use this discretionary authority to focus on specific industries that continue to create potential risks to human health and the environment.

While small quantity generators might be subject to such additional reporting responsibilities under this option, EPA could consider subjecting them to less rigorous and burdensome requirements than those affecting large quantity generators.

Other Options

A number of other waste minimization options have been identified in the course of preparing this report. A full list of available options is found in the technical support document for this report, *Waste Minimization Issues and Options*. Several of the options listed there are not discussed here for various reasons: either they have been considered already under other authority (such as the provisions for a waste-end tax now under consideration as part of the CERCLA reauthorization), or they have been found, on further review, to be unworkable as part of RCRA (e.g., enforcement bounties). Appendix B to this report lists options that have *not* been evaluated or presented here and explains the reasons for their exclusion.

Two basic options for waste minimization that the Agency believes should definitely be considered as part of a short- or long-term waste minimization strategy are (1) technical assistance for waste minimization, implemented in cooperation with the States, and (2) modifications to Federal procurement practices to avoid discriminating against recycled commodities and, where appropriate, to support development of markets in recycled commodities.

An active, aggressive, and sustained program for technical assistance appears to be the strongest option available to promote waste minimization, especially in the near term. Carried out in cooperation with the States, such a program could be aimed primarily at small[10] and medium sized companies, which currently have the least access to information on how to minimize their wastes. The program's purpose would be to encourage firms to include waste minimization efforts in their hazardous waste management planning, to provide access to technical information, and to encourage the development of markets for recyclers and recycled materials. No new legislative authority would be required to launch such a technical assistance effort, but adequate and sustained support by Congress would be necessary over the next ten years if it were to achieve its potential.

RCRA already provides authorization for EPA to encourage revision of Federal procurement practices to promote the use of recycled products. Section 6002 of RCRA requires procuring agencies to amend Federal procurement practices to avoid unnecessary discrimination *against* recycled products, and requires EPA to promulgate procurement guidelines that actively promote the procurement of recycled products. This strategy may help achieve substantial increases in the market share of recycled products, particularly where the Federal government is a major consumer of a product. In such instances, a Federal preference for a recycled product may make the product economically viable. EPA should work with agencies that are in the best position to create such markets, including the Department of Defense and the Department of Energy.

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[10] "Small" companies are not intended to include only Small Quantity Generators as defined under RCRA. A technical assistance program would also be useful for small quantity generators, but the degree of emphasis on this group would have to be carefully reviewed. While small quantity generators do need (and often request) technical assistance, the available data suggest, as noted earlier, that they contribute only a very minor fraction (about one-half of one percent) of hazardous waste volume nationally.

Recommendations

At this time, the Agency believes that generators should continue to determine which waste minimization techniques are economically practicable and that EPA should not specify requirements for waste minimization.

If, after implementation of the other pertinent provisions of the HSWA, the Agency decides that standards of performance or required management practices are needed to protect human health and the environment, it will then request the necessary additional authority from Congress. EPA proposes to report to Congress on this issue in December 1990, the earliest date at which it believes a recommendation on the need for a mandatory waste minimization program could be made.

EPA does plan to expand its waste minimization efforts as discussed below in the context of EPA's proposed three-point waste minimization strategy.

The elements of this strategy are:

1. **Information Gathering:** Detailed data on industry's response to the land disposal restrictions program and other existing waste minimization incentives must be gathered in order to make a final determination on the desirability and feasibility of performance standards and required management practices.
2. **A Core Waste Minimization Program:** During the interval when the new provisions of HSWA are taking effect, EPA will launch a strong technical assistance and information transfer program through the States to promote voluntary waste minimization in industry, government, and the non-profit sectors of the economy. It will also work with Federal agencies to encourage procurement practices that promote the use of recycled and reclaimed materials.
3. **Longer Term Options:** Based on an analysis of the new data gathered under (1) above, performance standards and other mandatory requirements can be imposed, if necessary, once the

HSWA amendments have taken full effect and their impacts on waste generation have been assessed.

Information Gathering

Agency actions to encourage waste minimization, whether through voluntary means or through future regulatory action, must be based on a full understanding of the present state of hazardous waste generation and management and of how that system is evolving under the many pressures to which it is now being subjected. The general patterns and trends of hazardous waste management systems are becoming clearer, but past trends may not persist through the next four to six years as HSWA's new provisions take effect, and as industry seeks to control the potential financial liabilities associated with hazardous waste management.

Baseline and trends data: The best data available to the Agency on the amount and content of hazardous wastes were developed by surveys conducted in 1981 and 1983. These data are rapidly becoming out of date and are known to be of uneven quality because of reporting errors and the small and variable sample sizes from which information was extrapolated. They must be supplemented with new data documenting the changes that have already begun and will continue to progress over the next few years.

In order to make a final determination on the desirability and feasibility of mandatory waste minimization actions, the Agency must be able to document unresolved environmental problems for which such a new regulatory program would be the appropriate response. Examples might be waste streams for which treatment and disposal capacity remains inadequate even after the land disposal restrictions have been in place for a year or more, or a future EPA determination that a particular type of hazardous waste treatment method does not, in practice, adequately protect human health and the environment.

The types of data needed include detailed baseline information on the volumes and toxicity of wastes generated, trends data on source reduction and recycling, trends data on treatment and disposal capacity, and analyses of the human health and environmental impacts of treatment and disposal practices. EPA expects that existing statutory authority is sufficient to gather this additional data. One potential source will the biennial reports, which will be upgraded to improve the consistency and coverage of the information submitted. Other sources may include a new generator survey or the 1986 TSD survey currently being undertaken, information developed by EPA programs outside of the Office of Solid Waste (such as under TSCA), and the reporting requirements that may be enacted under amendments to CERCLA.

Data to support technical assistance and information transfer: Much of the same data can be used to set priorities for technical assistance programs to promote source reduction and recycling programs, targeting them where they will be most successful in reducing threats to human health and the environment. However, in-house research and cooperation with States and industry trade associations will provide more detailed information on the cost and effectiveness of specific waste minimization techniques for the targeted industries. This information gathering program will enable EPA to develop an accurate profile of waste management trends and practices and selectively develop performance standards or other requirements as needed.

A Core Waste Minimization Program

As this report has already emphasized, it is neither desirable nor practical to research, promulgate, and enforce a major regulatory program mandating specific waste minimization standards over the next four to six years. During this time, industry will be making technical and financial commitments to respond to the changing requirements and incentives of the hazardous waste management system. Once made, these commitments will be difficult to change. It is therefore both practical and highly desirable to conduct outreach programs to support and enhance the use of waste minimization as part of an overall waste management strategy and to reduce threats to human health and the environment. It should be noted that, in the event that mandatory controls are needed in the near term to control volume or toxicity of wastes generated by particular industries, EPA would use the authority that currently exists under Section 6 of the Toxic Substances Control Act.

Elements of this initial waste minimization program will include:

- Development and publication of an Agency policy statement on waste minimization including non-binding guidance to generators defining what constitutes waste minimization under the reporting and certification requirements of HSWA. To the extent possible, this guidance will be specific to particular industrial sectors and processes.

- Expansion of EPA's role in providing for technical and information assistance to generators, including small generators. Because the States have more direct contact with the generators and hence have more awareness of generators' needs and problems, EPA's primary role should be to support and encourage the States in the development of their programs. An appropriate EPA-sponsored technical assistance effort includes the following elements:

  - Assistance for States to initiate and develop programs for providing direct assistance to generators, especially small and medium sized generators.

  - Technical support of research and development and economic feasibility studies that might serve an entire region or have regional application.

  - Development of a computerized information system on waste minimization, accessible by the States.

- Encouraging voluntary waste minimization concepts within the review of new chemicals mandated under TSCA Section 5. EPA anticipates the preparation of a New Chemicals Information Bulletin advising submitters that waste minimization will be considered during the review of the relative risks of the new chemical substances and their existing substitutes.

The Agency should also establish a formal process of coordination with the States to ensure a continuing and responsive technical assistance and outreach effort over the longer term.

In addition, EPA will continue to examine specific elements of the "core" waste minimization program and make recommendations for legislative changes to the existing waste minimization requirements, if needed, as part of the next RCRA reauthorization. Among the possible options to consider would be modifications to the existing certification for generators and TSDFs, including:

- Prohibiting, where appropriate, certification of certain types of waste management practices as waste minimization.
- Providing, where appropriate, formal guidance as to what may be certified as waste minimization. Such guidance could apply generally or to specific industrial sectors. (Flexibility for appeals and exceptions must also be provided.)
- Requiring generators who have not undertaken any of the approved waste minimization activities, but who certify that there is no economically practicable alternative to their present waste reduction and management practices, to provide a written explanation of such certification.

Longer Term Options

Only after the land disposal restrictions and other principal provisions of the HSWA go into effect, and after EPA has developed the needed additional data on hazardous waste generation and management, will it be possible to determine whether standards of performance (including phasedown permits) or required management practices (such as waste audits) are necessary to achieve additional reductions in the volume or toxicity of wastes. The Agency therefore recommends that consideration of new mandatory programs be deferred until after such data can be gathered and analyzed, and proposes to report back to Congress on the desirability and feasibility of prescriptive approaches two years after the first of the land disposal restrictions has been fully implemented. Excluding the possibility of case–by–case extensions, the first of the land disposal restrictions will be fully implemented in November of 1988; EPA will, therefore, make its next formal report on this subject in December of 1990.

Conclusion

EPA still has much to learn about waste minimization and recognizes that the cooperation of private and public waste generators will be invaluable as it moves toward the development of sound long term policy. It also believes, however, that the incentives and trends within the hazardous waste management system are unmistakable, and that the program presented here comprises the most positive and constructive steps that can be taken at this time. Aggressive action in favor of waste minimization is clearly needed, but a major new regulatory program—at least for the present—does not seem desirable or feasible.

Incentives for waste minimization are already strong, so EPA must capitalize on them. Most lacking is access by generators to the information that will demonstrate the economic benefits of waste minimization to industry, overcome logistical problems, and help develop creative new approaches. This can be provided by a strong technical assistance and information transfer effort, which can achieve through voluntary means what would be inefficient and possibly counterproductive to attempt through regulation. Unfortunately, non-regulatory programs have often failed at EPA for lack of statutory or regulatory deadlines and institutional advocacy. For such a program to work, it must be given strong organizational support within the Agency.

EPA is willing to make this commitment, and seeks support from Congress to ensure its success.

FACT SHEET

Waste Minimization Findings and Activities

U.S. Environmental Protection Agency

October 1986

FY 85-86: Activities

Developed waste minimization technical support document (TSD) entitled *Waste Minimization - Issues and Options*, which includes:

- Definition of terms
- National profiles of recycling and source reduction practices

Source Reduction Profile in TSD

- The following 22 production and manufacturing processes were studied for the source reduction component of the TSD:

Production processes included:

— Acrylonitrile
— Electroplating
— Inorganic pigments
— Organic dyes
— Petroleum refining
— Printed circuit boards
— Synthetic rubber
— 1,1,1-trichloroethane
— Vinyl chloride
— Agricultural chemicals
— Epichlorohydrin
— Metal surface treatment
— Paint manufacture
— Phenolic resins
— Printing operations
— Synthetic fibers
— Perchloroethylene
— Wood preserving

Manufacturing processes included:

— Good housekeeping
— Paint application
— Metal parts cleaning
— Process equipment cleaning

- These processes were selected from among 200 different industrial processes. Criteria for selection included:

  - — Large volumes of hazardous waste generated
  - — Toxic hazardous waste generated
  - — Waste generated is part of California list of hazardous waste

- In the past, industry typically considered the implementation of source reduction practices only if such practices resulted in improved product yield or lower manufacturing costs.

- Since about 1970, however, environmental regulations under RCRA, the Clean Air Act, and the Clean Water Act have also, to some extent, influenced the use of source reduction techniques. In some cases, source reduction has occurred as a direct consequence of regulation, such as under the Clean Water Act requirements regarding wastewater treatment.

- Based on the qualitative analysis of the 22 production and manufacturing industries, extrapolated to all hazardous waste generators, it appears that the level of waste generation in terms of unit of waste per unit of product has declined over the last 15 years. Preliminary estimates suggest that industry might be generating about twice the amount of waste per unit of production than it does at present if no source reduction techniques were in place today.

- The potential for future reduction of waste appears to be significant. Preliminary evidence suggests that, within the next 25 years, aggregate waste generation volumes can be reduced an additional 15 to 30 percent by the extension of existing source control techniques.

- Through further extension of good housekeeping practices, waste minimization appears most promising in the industries characterized by high labor utilization, or where batch processing is used. Good housekeeping will have only limited effect in large-scale continuous processes with a relatively high degree of automation.

- For continuous processes generating large volumes of waste, the most promising SR technique is technology modification. Input material alteration is most effective in those processes where impurities constitute a high fraction of input materials.

- In a chemical process, catalyst use and reactor design appear to have the strongest potential impact on waste generation. Improved catalyst selectivity, along with optimum reactor design directly affects the amount of waste produced.

Recycling Profile in TSD

- Of the 42,000 M gal. of hazardous waste generated by U.S. industries in 1981, 1,575 M gal. (4 percent) were recycled.

Waste Group	Percent Recycled by Volumes
Solvents (halogenated and nonhalogenated)	24.0
Metal-bearing	28.0
Corrosives	29.0
Cyanides and other reactives	20.0
Halogenated organics (nonsolvent)	< 0.1

- Three manufacturing industries, the *Transportation Equipment* industry (SIC 37), the *Chemicals and Allied Products* industry (SIC 28), and the *Primary Metals* industry (SIC 33) accounted for 89 percent of the total volume of hazardous waste recycled in 1981. In contrast, generators in the *Motor Freight Transportation* (trucking) *and Warehousing* industry (SIC 42) did not report any recycling.

- Of the waste recycled, 81 percent by volume was recycled on-site.

- The breakdown of volumes of hazardous waste recycled according to onsite and offsite recycling suggests that the volume of waste recycled onsite increases as the total volume of waste recycled increases (i.e., facilities that recycle larger volumes of waste are more likely to recycle onsite).

- Offsite recycling accounted for the disposition of approximately 65 percent of the hazardous waste generated by SQGs in 1984. (Another 6 percent was recycled onsite.)

- Hazardous waste recycled in the greatest volume are dilute waste streams whose constituents can be reused in large-scale operations. This is true for the three highest volume waste streams recycled in 1981.

    - Spent acids and alkaline solutions (D002) recycled in large volumes by the *Chemical and Allied Products* industry and the *Machinery-Except Electrical* industry.

    - Wastewater treatment sludges from electroplating (F006) and chromium plating solutions (D007) recycled by the *Transportation Equipment* industry.

    - Pickle liquor (K062) a corrosive, metal-bearing waste, recycled mainly by the *Primary Metals* industry.

— These four waste streams account for 49 percent of total volume of waste recycled in 1981.

- Suitability for recycling is dependent upon market demand for and purity of the material.
- Data indicate that the higher the weighted average concentration of known constituents in a waste stream the more probable the use of recycling as a waste management option.

Other FY 85-86 Activities

Regulatory

- Implementation of HSWA waste minimization requirements on manifest, condition for onsite permits, and biennial reports.
- Providing informal guidance to generators on waste minimization

  — Solvent recycling
  — Offsite recycling (in general)
  — Participation in a waste exchange

Technical and Financial Assistance

- $4.75 million were available in supplemental grant funding to EPA Regional Offices; waste minimization activities were eligible for funding. Several waste exchanges have received funding.
- EPA's Office of Research and Development (ORD) Small Business/SQG Research Program has partially funded waste minimization programs in Minnesota and North Carolina.
- ORD also administered funding to Tufts University for study on foreign practices in waste minimization (Japan, Canada, Western Europe).
- ORD's Hazardous Waste Environmental Research Laboratory (HWERL) conducted research on waste minimization techniques in printed circuit board industry.
- HWERL is also developing a waste audit procedure and conducting audits at eight hazardous waste facilities. Facilities were chosen based on previously identified waste groups, e.g., solvents, corrosives.

Information Sharing and Management

- EPA co-sponsored the 1985 conference, *Waste Reduction - The Untold Story*, in Woods Hole, Massachusetts.
- EPA co-sponsored the 1986 conference, *Waste Reduction - The Continuing Saga*, in Woods Hole, Massachusetts.
- EPA co-sponsored in June 1986, *The Third National Roundtable of State Waste Reduction Programs.*
- In November, EPA will be hosting another meeting of the *State Waste Reduction Programs.*
- EPA staff have made waste minimization presentations at more than 15 national conferences.

FY 87 Activities

- Development of non-binding guidance on what practices constitute waste minimization.
- Development of new waste minimization biennial report data sheet for more consistent and accurate data collection.
- Development of technical transfer documents from information/data collected in the waste minimization TSD.
- Development of a computerized waste minimization information/data bank accessible by States and industry.
- Continued R&D on waste audits and development of technical transfer documents.
- Incorporation of Waste Minimization in TSCA Premanufacturing Notices.